Wireless World

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Political Television

WHEN the Government's proposals for competitive television were first put forward, this journal expressed the opinion that they lacked the air of reality. We found it hard to visualize the setting-up of a commercial service in the foreseeable future. Worse still, it seemed likely we were to get the worst of both worlds. Commercial television might not become established, but the promise (or threat, depending on one's personal view) of it might hamper orderly technical development by distracting attention from the essentials.

Now, nearly two years after this controversy was started by the issue of a new and "non-exclusive" licence to the B.B.C., Britain seems no nearer the establishment of a successful competitive television service. True, there has been a long succession of White Papers, reports and Parliamentary debates, culminating in the Television Bill now before the House of Commons, but to us and to many others the Government's plans look even less realistic than they did in 1952. There is at present a lull in the functioning of the legislative machine, and so the time seems appropriate for taking stock.

The Government has been widely commended for listening to criticisms of their original ideas and, indeed, they have gone far to meet them. Starting with the idea of full-blooded commercial competitiveness with sponsored programmes almost on American lines, they have gone all the way to the watered-down shadow of the B.B.C. represented by the proposed "Independent Television Authority" proposed in the Bill. Almost every detail of the original scheme has been abandoned except the principle of dependence on advertising revenue by the competitive system. Even that basic principle has been watered down by the proposed grant of £750,000 a year to the I.T.A. to meet the cost of what are called in America "sustaining programmes." The latest scheme seems unlikely to attract the kind of commercial support that is necessary for its success. As the *Financial Times* said, "The Government has now spent the better part of two years backing away from its own principles. . . . If all these precautions, in such an endless succession, really are necessary, then the system stands condemned that needs them; if they really are enforced they could condemn the system to which they are applied. . . . Between the political risk and the financial, the companies which put their capital into this will need both courage and imagination."

Though, as we have said, the Government is to be commended for attempting to meet criticism, they cannot be praised for their general handling of the matter. Probably the worst mistake was in the selection of their advisers, the Television Advisory Committee, which we criticized at the time as a queer and ill-assorted body for such a task. The T.A.C. was originally appointed with the widest terms of reference, but, no sooner did its membership come under criticism than we were told it was primarily appointed to advise on technical matters—in spite of the fact that none of the members had technical qualifications! Next, presumably to remedy this deficiency, a strong technical sub-committee was appointed, thus making the advisory machinery unnecessarily cumbersome.

In spite of having tried everything, the Government has failed to produce a scheme for commercial competitive television that arouses the slightest enthusiasm. So far as radio circles are concerned, we have heard little that amounts even to lukewarm approval, whether from the technical or professional branches, from industry or the trade. The scheme is widely considered to be wasteful and inefficient, and unlikely to lead to the healthy development of television. Heated discussion of matters of merely political significance has distracted our attention from the real technical problems. The only genuine supporters of the Bill are probably those who, fearing the effect of television advertising, feel the scheme proposed is foredoomed to failure and so it is in their interest to foster it.

Components Exhibition

Trends in Developments Portrayed at the R.E.C.M.F. Show

We review in these pages the trends in design and manufacture of components and accessories shown at the eleventh annual exhibition organized by the Radio and Electronic Component Manufacturers' Federation. Although a "private exhibition," the show, held in London from April 6th to 8th, again drew large crowds, including many overseas visitors. In addition to describing in detail some individual components, we give under each heading a list of exhibitors and their principal products. Test and measuring equipment, valves and semi-conductors are not included in this review, but will be covered in our survey of the Physical Society exhibition in the next issue. New sound-reproducing equipment will also be described later.

RESISTORS

ONE of the newest developments in resistor construction is the metallized film technique which provides very high stability under conditions of widely varying temperature. The basic principles were illustrated by one exhibit on the Ministry of Supply's stand. A metallic oxide film (tin is one of the constituents) is fired at 600°C on to a small-diameter glass tube or rod, the ends are plated and silvered, and connecting wires soldered on. The metal film is then cut spirally to provide the required resistance value and finally coated or encased to protect the surface. A 4-kΩ resistor of this kind has a temperature coefficient of 0.0003 and showed no change after 2,000 hours' use.

In production form it is exemplified by the Painton "Metholm" and the technique is applied also to attenuator plates and potentiometer tracks. Welwyn also has a range of metal-film, high-stability resistors on glass rods suitably protected.

Apart from detailed improvements and some additions to existing types, several firms, prominent among which is Erie, have developed special sub-miniature ranges of resistors principally for use with transistors. Low current consumption allows the use of $\frac{1}{8}$- or $\frac{1}{10}$-watt resistors.

An unusual use of a surge-limiting resistor, such as a Brimistor (S.T.C.), is to protect the contacts on mains switches embodied in volume controls and such-like composite components. A special type (the CZ9A) is available with operating resistance of 5.2 Ω at 1 A and a "cold" resistance of 800 Ω.

Makers*: A.B. Metal (C, W); Advance (A); Brit. Elect. Res. (W); Colvern (W); Dubilier (C, H, W). Egen (C); Electronic Comp. (A, W); Electrothermal (H); Erg (H, W); Erie (C, H, W); Morganite (C); N.S.F. (C, W); Painton (A, H, W); Plessey (C, W); Pye (W); Welwyn (C, H, W).

* *Abbreviations:* A, attenuators; C, carbon; H, high stability; W, wirewound.

CAPACITORS

A NEW type of electrolytic capacitor was shown this year by T.C.C. Known as the Superlitic, it has an insulation resistance comparable to that of a paper-dielectric type and so can be used for grid coupling in audio amplifiers where large capacitance in a small volume is required.

New developments in the capacitor field were seen also, among the Ministry of Supply's exhibits where a type was shown described as a "metallized anodic aluminium film capacitor." It consists of a thin aluminium foil coated with a 0.2-mil thick layer of aluminium oxide on which is deposited by evaporation a 0.2-mil thick layer of aluminium. It is said to have self-healing properties and produces 1 μF of capacitance per 200 square centimetres of material and shows a good power factor.

The likelihood of Band III television and Band II sound broadcasting coming to fruition shortly has led this year to greater prominence being given to all types of v.h.f. capacitors than might otherwise have been the case. Cyldon has an extensive range of air-dielectric trimmers and variables of less than 1 cu in, which provide capacitances up to 30 pF maximum; Eddystone has a new range of miniature Microdensers, including single, split-stator and butterfly types, the largest being 50 pF, and Erie has a wide range of "high k" ceramic pre-set trimmers, stand-off and lead-through capacitors for direct fixing to the chassis.

By-pass capacitors are usually soldered in place, but the pre-sets generally have a "Spire" or similar type of fixing. Other examples of this type are made by Cyldon, T.C.C. and Wingrove and Rogers.

Dubilier has a new miniature ceramic television by-pass capacitor which possesses practically negligible inductance up to and beyond Band III frequencies. It is suitable for by-pass and lead-through applications and is fixed by soldering to the chassis. The nominal capacitance is 1,500 pF.

A new two-gang tuning capacitor introduced by Plessey has separate sections for tuning the v.h.f. circuits of a combined f.m. and normal broadcast receiver. Extra thick vanes are used to prevent microphony and give stability for the v.h.f. sections, which also have separate rotor connections.

Makers*: B.I. Callenders (P); Cyldon (V); Daly (E); Dubilier (C, E, M, P, V); Eddystone (V); Erie (C, V); Hunt (E, M, P); J.B. (V); L.E.M. (C, M); Mullard (V); Plessey (C, E, V); S.T.C. (E); Stability Radio (C, M); Static Cond (P); Suflex (F); T.C.C. (C, E, F, M, P, V); T.M.C. (F, M, P); Walter (V); Wego (F, M, P); Welwyn (V); Wingrove and Rogers (V).

**Abbreviations*: C, ceramic; E, electrolytic; F, plastic film; M, mica, including silvered mica; P, paper; V, variables, including trimmers.

TRANSFORMERS AND COILS

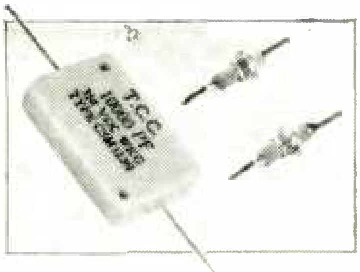
LAST year saw the introduction by Ferranti and Parmeko of iron-cored transformers encased in a particularly tough potting resin. It effectively seals the components and inhibits the ingress of moisture and is especially suitable for tropical conditions.

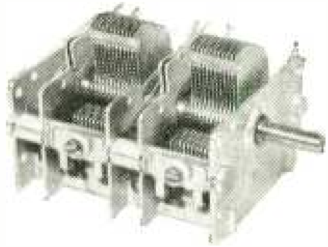
This year the technique is extended to certain models made by Gresham, Whiteley Electrical and Woden; while the resins are substantially the same in character they differ widely in appearance and each make is quite distinctive. High pillars can conveniently be cast in the moulding process should it be necessary to provide extra long leakage paths for high-voltage terminals.

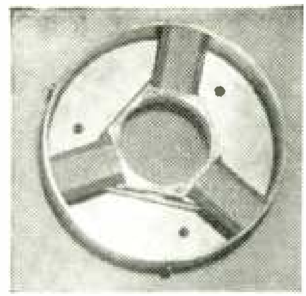
When v.h.f. broadcasting becomes an established service, transformers for high-quality reproduction will be more in demand than is perhaps the case at present. In anticipation of this Partridge has produced an output transformer with a response characteristic flat to within ±0.5 db from 30 to 30,000 c/s. Known as the Type UL2 it has a primary inductance of 200 H in push-pull operation and is rated at 50 W from 60 c/s up and 14 W at 30 c/s.

Radio-frequency coils remain substantially unchanged although Weymouth has a few new miniature types. For f.m. receivers Eddystone has a range of transformers and discriminators for i.f.s of 5.2 and 10.7 Mc/s. They measure $\frac{11}{16}$ in square and $2\frac{1}{2}$ in high and conform well to modern schemes of miniaturization.

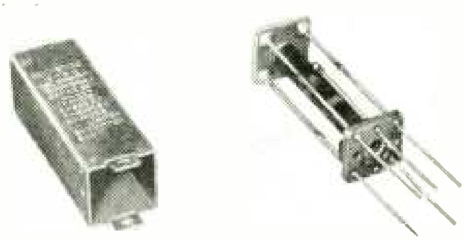
Makers: Advance, Associated Electronic, Bulgin, Elac, Ferranti, Gresham, Igranic, Parmeko, Partridge, Plessey, R & A, Rola-Celestion, T.M.C., Weymouth, W.B., Woden, Wearite.







Left : T.C.C. moulded "Plimoseal" capacitor and v.h.f. lead-through capacitor. Centre : Plessey a.m. f.m. two-gang capacitor with extra rigid v.h.f. capacitor vanes. Right : Interior of James Neill focus unit with three radial magnets.



Eddystone 10.7-Mc s. f.m. discriminator unit.

TELEVISION COMPONENTS

ALTHOUGH hardly components in the accepted sense of the word, television tuners are conveniently dealt with under this heading. They are actually sub-assemblies which accept an r.f. input and provide an i.f. output. Such tuners are new to British television for, although certain models have been shown in previous exhibitions, they have hitherto been intended for the export market. It is the prospect of alternative television programmes that has made it necessary to provide British receivers with some form of rapid station selection.

The tuners exhibited are all fundamentally of the same nature and are of the turret type. Provision is normally made for 12 channels, five on Band I and up to seven on higher frequencies. The valves and main components are assembled on a small and deep chassis with the coil connections terminating on spring contacts. The coils are assembled in a rotating framework—the turret—each coil or group of coils being mounted on an insulating strip bearing contacts which press against the springs. Rotating the coil assembly brings each coil in turn not only into electrical circuit but physically into a position where it is connected by the shortest possible leads.

The electrical circuit usually comprises a double-triode connected as a cascode r.f. amplifier and a triode-pentode acting as a mixer and oscillator. There are three coils for each channel, one for the aerial coupling, one for th intervalve coupling and one for the oscillator. The inter valve and oscillator coils are usually mounted together or one contact strip, but the aerial coil is separate on a second contact strip. This is done so that screening can be inserted between them.

Screening is actually quite an important matter, not so much to maintain stability as to minimize radiation from the oscillator.

The Cyldon unit has been available for some time in a five-channel form for Band I only and a 12-channel model originally designed for export. The Ediswan-Clix tuner is a newcomer. The coils have brass slugs for trimming. One coil for each channel is mounted longitudinally with its trimmer accessible from the end; the other two are mounted radially and the trimmers can be reached from the outside surface of the turret. In the Plessey tuner, however, all coils are longitudinally mounted and the trimmers are accessible from the two ends, one core being hollow to permit a tool to pass through to reach the middle one.

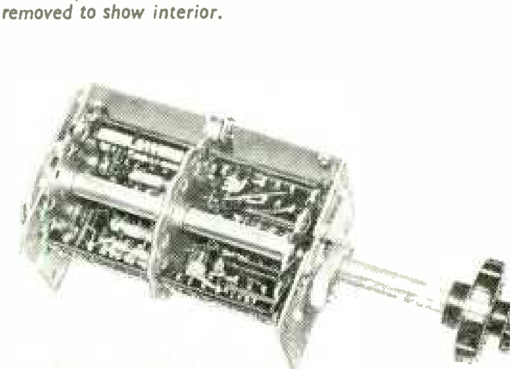
An unusual r.f. component is the Labgear television high-pass filter. This is a small unit for inserting in the aerial feeder to the set. In Band I it introduces a loss of 0.7-1 db only but at 35 Mc/s it attenuates by some 20 db and at 30 Mc/s by 40 db. At lower frequencies the attenuation is still higher. Its purpose is to prevent interference from signals on the frequency of the i.f. amplifier.

Little change has taken place in scanning circuits or components for them. Line-scan transformers and deflector coils with ferrite, or similar, cores are now general and changes are in the matter of detail only. More development seems to have occurred in focusing components. The permanent magnet appears to have come to stay and only one example of an electromagnet (Igranic) was noticed. The difficulty with a p.m. system is always to obtain an adjustable field and, hitherto, the favourite method has been to use two ring magnets in opposition. Examples of this are the Electro Acoustic Industries Duomag unit, introduced some time ago, and the new and more compact Duomagnette. In these, the magnets are Magnadur rings and the field strength is controlled by varying their spacing. This same basic form of construction is adopted by Goodmans in a unit which embodies shuffle-plates for picture centring.

A radically different form of construction is adopted by James Neill. Three short bar magnets are mounted radially between a central hollow core and a pressed steel case. The case is in two parts movable with respect to each other. There are two air gaps, one between the core and one half of the case and the other between the core and the other half. One gap is fixed; the other gap is adjustable for focusing by moving one half of the casing. The unit is compact and is claimed to make very economical use of the magnetic material and to have a very small external field; so small in fact that a shuffle plate cannot be used for picture centring. A similar form of construction is adopted by Marrison and Catherall.

Ion-trap magnets and centring magnets are further

Turret of Ediswan-Clix television tuner with some coil units removed to show interior.



devices to which the permanent magnet finds application. In the latter, the tendency is towards the use of a pair of ring magnets which can be rotated to act in opposition or to help each other as a means of varying the field strength. In their simplest form, they are wire rings mounted on cards for adjustment purposes.

* **Makers:** Cyldon (T); Carr Fastener (C); Ediswan-Clix (T); Electro Acoustic Industries (F); Goodmans (F); Igranic (D, F, Tr); Labgear (Fi); Long & Hambly (M); Marrison & Catherall (F); James Neill (F); Plessey (D, F, T, Tr); Thermo-Plastics (M); Weymouth (D, Tr); W.B. (D, F, Tr).
**Abbreviations*: C, connectors; D, deflector coils; F, focus units; Fi, filters; M, masks; T, tuners; Tr, transformers.

SUB-ASSEMBLIES

WHERE space is at a premium, as it seems to be in most Service equipments, the resin potting technique, as applied to sub-assemblies, has definite advantages. It enables the three-dimensional form of construction to be fully exploited as components can be stacked vertically to any height in a secure fashion, thus saving valuable chassis space. This is well exemplified by the various potted assemblies included in the Gresham and Whiteley Electrical exhibits.

Printed circuitry was not much in evidence, although Hunt had several examples and Erie are using it for various resistance-capacitance units in order to save space and receiver assembly time.

Television suppressors figured among the exhibits of several firms. Dubilier showed a number of new types, also separate components in the form of special capacitors and chokes for fitting inside small electrical tools and domestic appliances. Belling-Lee has various types; one, the "Telefilter," as it is called, is joined in the mains lead to the device and contains a pair of r.f. chokes giving 20-db suppression over 40-70 Mc/s.

AERIALS

DESPITE uncertainty regarding the actual requirements for Band III television, Aerialite, Antiference, Belling-Lee and Wolsey all showed prototype models of new aerials. Most makers seem to anticipate that 4- or 5-element yagis will be the popular type in areas normally served by "H" aerials on Band I. As the polarization question is still fluid no attempt was made to combine Band I and III aerials.

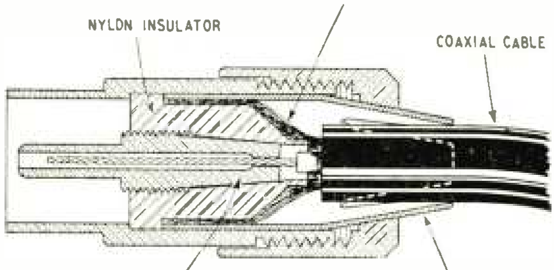
Apart from these prototypes the main changes have been in details only. For example, Belling-Lee has a new flush-fitting coaxial chassis socket, the first departure from the customary stand-off pattern; Wolsey has evolved a solderless coaxial cable plug in which the outer braiding and the centre conductor are simultaneously secured by tightening the milled head. The insulator is nylon. Wolsey also has added a "delta" matching section to its "X"-type aerials fitting conveniently in the angle of one of the two "Vs." As the centre impedance of this type of aerial is rather low, the better matching to the feeder must lead to a worth-while improvement.

Some extremely attractive miniature coaxial plugs and sockets were seen on the Transradio stand and Pye was showing a sealed coaxial plug and socket for television and radar use, as well as a range of the more elaborate design which has become familiarly known as the "Pye" plug and socket.

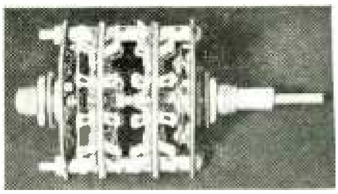
Makers*: Aerialite (B, C, S, T); Antiference (B, C, S, T); B.I. Callenders (C), Belling-Lee (B, C, S, T); Henleys (C), Pye (S), Transradio (C, S); Wolsey (C, S, T).
**Abbreviations*: B, sound broadcast; C, cables and feeders; S, socketry; T, television.

SWITCHES

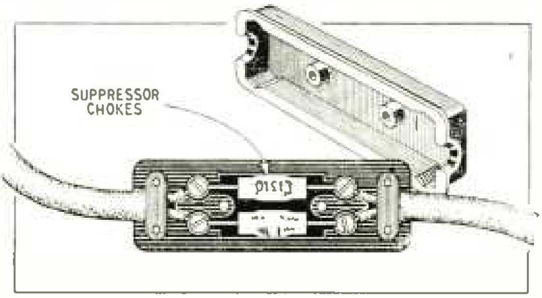
A DOUBLE rotary switch with its two wafers independently controlled from the same shaft was an interesting feature of the Walter Instruments display this year. The trick is accomplished with concentric spindles, an outer one controlling the near wafer while a thin inner one passes right through its middle to the second wafer



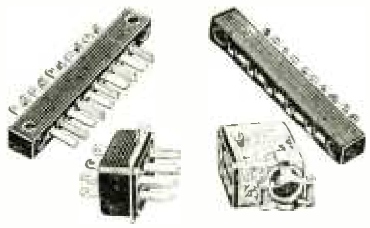
Wolsey "no soldering" coaxial cable plug.



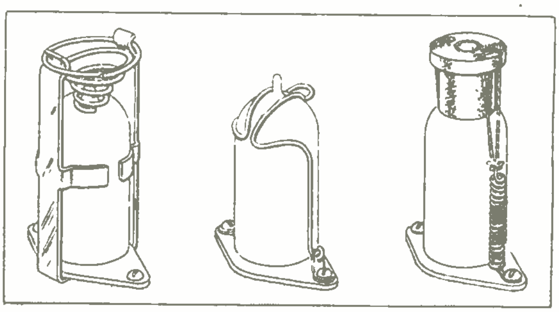
Rotary switch by Walter Instruments with independent coaxial spindles controlling two wafers.



Belling-Lee "Telefilter" appliance suppressor.



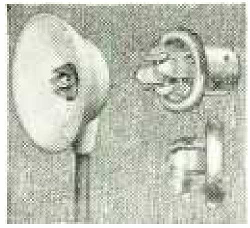
Painton miniature plugs and sockets.



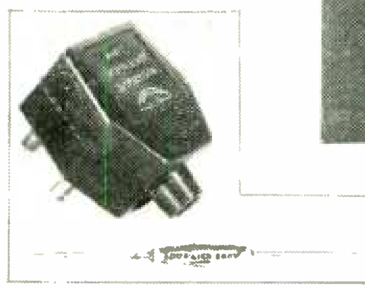
Different methods of retaining valves as exemplified by (left to right) McMurdo, Spear and Electrothermal.

behind. Another similar device was a rotary switch with a hollow spindle designed to accommodate the shaft of a potentiometer; versions were shown by both Walter Instruments and Plessey. High insulation resistance was the main feature of a new rotary switch by N.S.F., which had almost all its working parts, except the wafer, moulded in Nylon. The well-known micro-switches made by Bulgin have now been incorporated in a new kind of multiple switch. They are ganged together and operated by Bakelite cams on a rotating control shaft; up to 12 units can be assembled in this way.

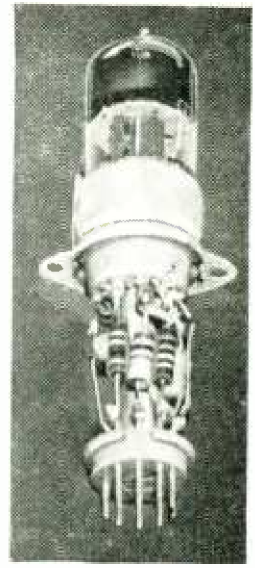
Makers: A.B. Metal Products; Belling-Lee; B.E.R.C.O.; Bulgin; Diamond H Switches; Electronic Components; Electrothermal Engineering; Erie Resistor; N.S.F.; Painton; Plessey; Pye; T.M.C.; Walter Instruments; Whiteley; Wright and Weaire.



(Above) Anode-cap connector for c.r. tubes with recessed caps (Carr Fastener).



(Below) Dubilier suppressed mains plug and television suppression choke for small electric appliances.

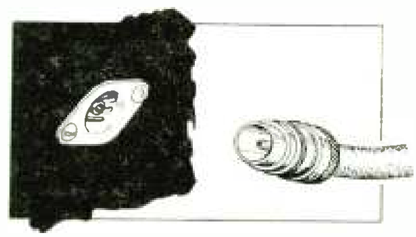


(Above) McMurdo valve-circuit support.

CHASSIS FITTINGS

TWO topical items on the Carr Fastener stand were sockets for transistors and valveholders for printed circuits. The transistor holders were basically the same as B5A sub-miniature valveholders, only with three sockets (or four for the new tetrodes) instead of the usual five. The valveholders, moulded in a thermo-setting material called Mikacin, have short tags which go through holes in the printed circuit base-plate and are bent over and soldered on to the printed "wires." Some multi-way plugs and sockets shown by this firm also had bodies moulded in Mikacin. A special feature of these was the design of the socket unit, which had 16 spring fingers gripping the inserted plug pin, thereby giving very low contact resistance. A set of spring fingers was also used in an anode-cap connector intended for the more recent cathode-ray tubes with recessed caps.

On the subject of making connections, Belling-Lee were showing a new terminal which will make contact with cables without the necessity of stripping their insulation. A set of teeth inside the terminal pierces the insulation and grips the conductor when the top is screwed down. Another interesting connecting device, shown by McMurdo, was a multi-way tag-strip in rod form which can be built up as required from double-ended soldering tags sandwiched between Bakelite spacers on a screw or rod.

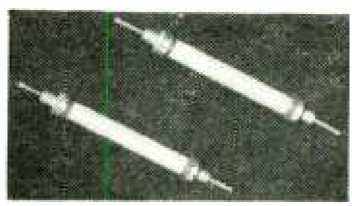


(Right) Belling-Lee flush-fitting coaxial socket.

There were quite a few different types of valve retainers to be seen, perhaps the simplest being an ingeniously bent piece of wire on the Spear Engineering stand. For securing flying-lead valves McMurdo had a PTFE holder, with tags to which the leads are soldered, with a metal envelope-clamp, made in two interlocking sections, which grips the bulb along its entire length and helps to conduct the heat away.

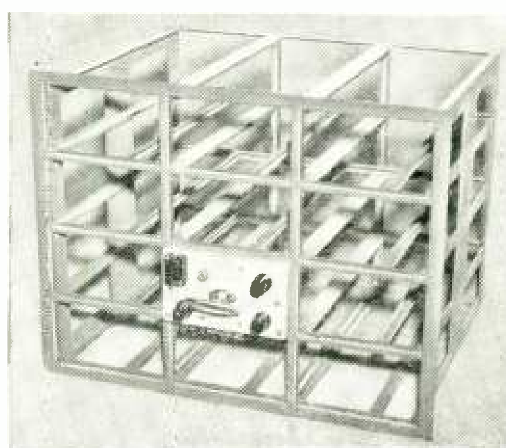
The unit-construction principle was represented in two different ways. First, by a "honeycomb" type of steel rack, on the Hassett and Harper stand, designed to accommodate a large number of small slide-in chassis of miniaturized equipment. Secondly, by an interesting type of valve-circuit assembly which carries the valve and all the associated components required for a complete functional unit—say a binary counting stage. The valve-circuit components are wired between the base of the valveholder and a circular platform, containing soldering tags, mounted below it on a central supporting column.

An unusual type of ceramic coil former shown by the United Insulator Company was fitted with dust-core tuning slugs and adjusting screws at both ends, the design being suitable for an i.f. transformer. This firm also had an insulated lead-through with the extra feature of a metal flange round the ceramic tube for fixing it to the chassis.



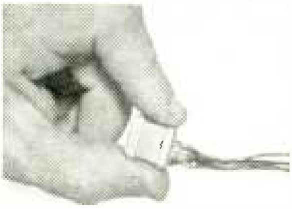
(Left) Coil former with dust-core tuning slugs at both ends, made by United Insulator Company.

(Below) Hassett and Harper "honeycomb" rack for miniaturized equipment.

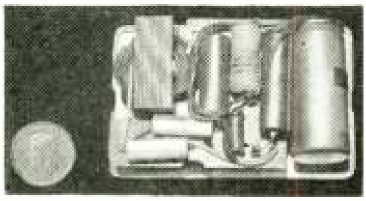


VIBRATORS AND RELAYS

IN order to produce a really light-weight vibrator power supply for the airborne units of a radar sonde, Wimbledon Engineering have designed a vibrator which weighs less than 1 oz. It has no bob on the vibrating armature and operates at about 400 c/s. Working from a



(Left) Miniature relay shown by the Ministry of Supply.



(Right) Wimbledon light-weight vibrator power pack compared with a florin for size.

(Left) Solenoid-type balanced relay by Pye.

6-V or 12-V battery, it will give an h.t. supply of up to 50 mA at 100 V, 0.6 mA at 800 V or 3 μA at 1,000 V, and has an average life of about 200-250 hours. It is a non-synchronous type, the rectification being done by selenium rectifiers following a step-up transformer. The complete power pack weighs under 8 oz.

For airborne units of a more deadly type the Ministry of Supply were showing what must be one of the smallest relays in existence. Fitted into its case, it measures approximately $\frac{1}{2}$ in cube and weighs $\frac{1}{4}$ oz. The armature is in the form of a partially rotating shaft and requires an operating power in the energizing coil of 700 mW. The platinum contacts will switch circuits carrying up to 300 mA or 100 V, while the whole device will withstand accelerations of up to 12 g.

Another relay designed for operation under conditions of high acceleration was shown on the Pye stand. This works on the solenoid principle, the contacts being operated from the sliding-rod armature through a lever mechanism. One advantage of this type of action is that it avoids contact sticking. The contact combination has two poles normally open and two poles normally closed and will carry up to 20 A at 24 V.

Other influences which can affect the operation of a relay are changes in temperature and external magnetic fields. In the Plessey voltage regulating relay (designed to maintain constant the input voltage to vibrator power supplies) temperature compensation is provided by an external swamp resistance of zero temperature coefficient and a bimetallic strip which varies the tension of the control spring. The effects of magnetic fields are eliminated by a screening container. In addition the Radiometal armature is balanced for stability under mechanical shock.

Makers*: Plessey (V), Pye (R); S.T.C. (R); Stratton & Co. (V); T.M.C. (R); Walter Instruments (R); Wimbledon Engineering (V); Wright & Weaire (V).

**Abbreviations*: V, vibrators; R, relays.

MATERIALS

FULL advantage is being taken by wire manufacturers of new synthetic plastic insulants in producing improved coverings for "enamelled" wire. In addition to the established oil-based and vinyl acetal, coatings are now available in silicones for high-temperature working, and development is proceeding with a new substance—polyurethane—which, in addition to possessing the primary properties of good flexibility and abrasion resistance, has favourable characteristics as a soldering flux. For purposes where a woven textile covering is required, Terylene fibre is now offered as an alternative to silk and cotton. In addition to its improved moisture temperature and abrasion resistance, Terylene is immune from attack by fungi and bacteria.

Methods of extruding p.v.c. sleeving in striped multiple colours for wiring identification have been developed by several firms, and H. D. Symons were showing coloured silicone sleeving with bores ranging from 0.5 to 12 mm.

Resistance wire made by Vactite is now drawn to a diameter of 0.0005 in—half the thickness of 50 s.w.g.

Fine meshes for valve electrodes, fabricated by Murex in molybdenum and tantalum, include an expanded metal mesh which is an outstanding example of the art of the stamper and piercer.

Among cables for high frequencies a new helical-membrane 75-Ω coaxial of $1\frac{3}{4}$ in diameter (Type HM7A1) is being made by Telcon, who are also adding a duplicate series of 50-ohm cables to the range. B.I. Callender's Cables showed a range of couplers for their r.f. cables which includes the Mark IVa which is smaller than those used for television camera cables and has been designed for centimetre communication equipment. Screened "quad" cables for television relay distribution were shown by Telcon.

The special properties of nickel in forming a close bond with ceramic materials is being exploited by many of the insulator manufacturers in producing more reliable bushes for hermetically sealed components. Barium titanate ceramics for supersonic transducers are available from Plessey under the trade name "Casonic."

A new ceramic insulator "Faradex H," with a permittivity of 3,200 has been developed as a dielectric for bypass capacitors by Steatite and Porcelain Products, who have also introduced "Frequentite S," a steatite-type material with a loss (tan δ) of less than 0.0002. It is free from porosity and can be used as an envelope for e.h.f. valves.

Silvering solutions for depositing electrodes on ceramic insulators are now available from the United Insulator Company.

A mica-loaded vitreous material, "Mycalon," developed by the Mycalex Company contains a low-melting-point glass which enables it to be injection-moulded. It complies with Inter-service Specification R.C.S.11 (accelerated tropical humidity) and its initial surface resistivity of 10^{15} is recovered within $1\frac{1}{2}$ to 2 hours.

Multicore solders now contain five cores, and "362" fast-flux cores and extra-fast "366" can be supplied, if required, without extra cost. One of the problems of efficient soldering is to ensure rapid release of the flux core, and in the latest Enthoven special solder washers the sheet material from which they are stamped contains a striped flux core which leaves microscopic vents at the edges from which the flux can escape before the solder melts.

Makers*: Associated Technical Manufacturers (B, C, IM, IS, W); Bakelite (IM); Geo. Bray (CE); B.I. Callenders (C, CO, IS, W). British Moulded Plastics (IM); Bullers (CE); Clarke (CF, IM, IS); Connollys (IM, W); Creators (IS); De La Rue (IM); Duratube and Wire (C, CO, IS, W); Enthoven (S); Fine Wires (W); Hellerman (IM, IS); Henley's (CO, IM, W); London Electric Wire (CO, W); Long and Hambly (IM, IS, RP); Magnetic and Electrical Alloys (L, M); Marrison and Catherall (M); Micanite and Insulators (CF, B, CO, IM, IS); Mullard (DC, M); Multicore (S); Murex (RM, M); Mycalex (IM); James Neill (M); Plessey (CE); Reliance Wire (B, C, CO, IS, W); Salford (DC, M); Geo. L. Scott (L); S.T.C. (M); Steatite (CE); Suflex (B, CO, IM, IS, W); Swift Levick (M); H. D. Symons (IM, IS); Telcon (C, DC, L, M, RM, W); Thermo Plastics (CF, IM); Transradio (C, IS, W); Tufnol (M); United Insulator (CF, CE, IM); Vactite Wire (RM, W).

**Abbreviations*: B, braiding; C, cables, CE, ceramics; CF, coil formers, bobbins; CO, cords; DC, dust cores; IM, insulating materials; IS, insulating sleeving; L, laminations; M, magnets and magnetic alloys; RM, refractory metals; RP, rubber products; S, solder; W, bare or covered wires.

Band III Convertor

Simple Circuit for Adapting Band I Television Sets

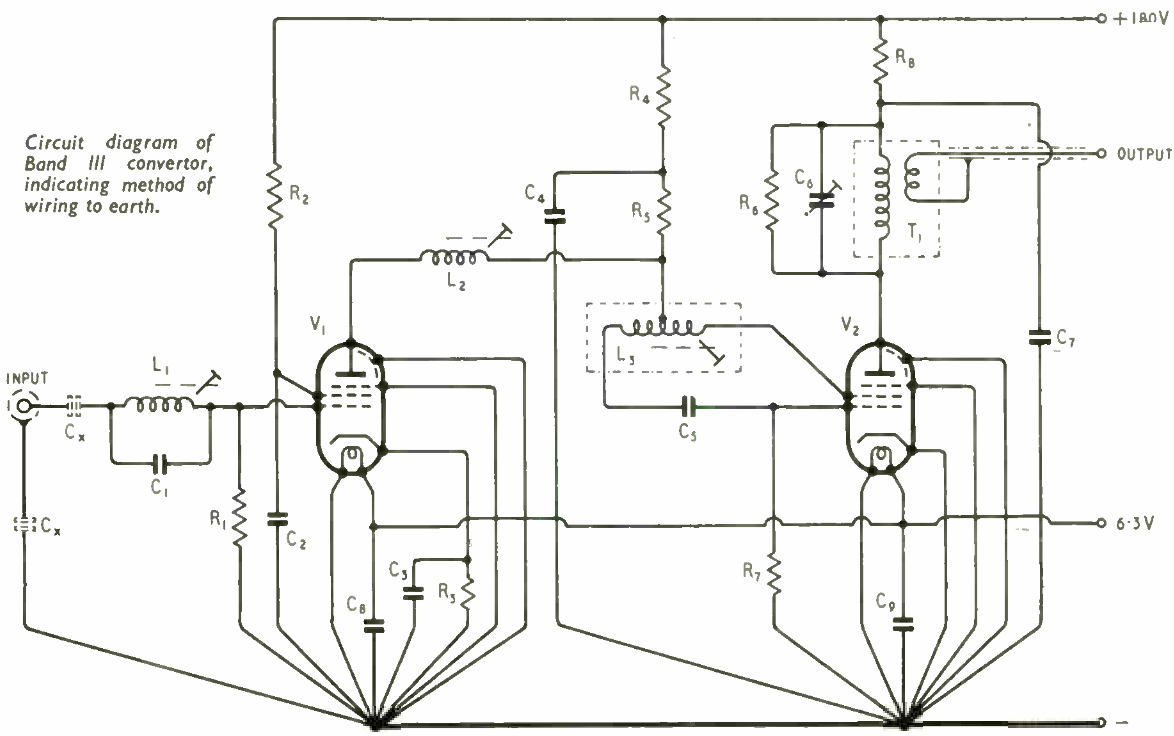
By G. H. RUSSELL, Assoc. Brit. I.R.E

VARIOUS Government pronouncements of recent date have made it clear that television broadcasting on Band III is imminent. For this purpose two channels have been made available between 186 and 196 Mc/s. It is also apparent that no further channels in this band will be placed at the disposal of television broadcasting for some considerable time, and this limitation means that for some years only one programme in Band III will be receivable in any given area. Receivers capable of covering both Bands I and III are appearing in the shops in increasing numbers, and in due course only this type of receiver will be available. In the meantime, large numbers of perfectly good single-band receivers will require convertors if their owners are to receive the alternative programme.

As the two available channels are adjacent to one another and as only one of these will be required in any one location, it is possible to construct an extremely simple pre-set-tuned convertor. It is obviously desirable that no re-tuning of the receiver should be necessary when changing stations. To achieve this the convertor intermediate frequency must be tunable over the greater part of Band I, and the convertor must be capable of tuning to either of the two channels in Band III with an i.f. corresponding to any one of the five channels in Band I. It is also highly desirable, if not essential, that the sound and vision signals be presented to the receiver in their normal relationship, that is, with the sound signal lower in frequency than the vision signal. Otherwise trouble may be experienced with sound rejection. This requirement necessitates the oscillator frequency being on the low side of the signal frequency. From the foregoing the following facts can be derived. The convertor i.f. should be tunable between the approximate limits of 45 and 68 Mc/s and the oscillator between 120 and 150 Mc/s.

The circuit of a convertor that will satisfy these requirements is shown in Fig. 1. A self-oscillating type of mixer (which is very efficient) is used and its output is fed to the receiver via the step-down i.f. transformer T_1. The primary of this transformer is tunable over the required range with an air-spaced trimmer and is shunted by a resistance to ensure adequate bandwidth. The oscillator is a conventional Colpitts circuit with the screen grid of the valve acting as the oscillator anode, the tuning

Circuit diagram of Band III convertor, indicating method of wiring to earth.



capacitance being provided by the internal capacitances of the valve and the external capacitances of the valveholder and wiring. Tuning is effected by means of an iron-dust core, and as the range will be affected to a considerable extent by the wiring it may be necessary to adjust the turns-spacing of the coil and to add a small capacitor, between 1 and 3pF, across the coil if it is desired to cover the whole range. On the other hand, as it will almost invariably be required to cover only a part of the range for any given reception area, adjustment of the coil should prove sufficient by itself. It is of interest to note that to achieve the wide tuning range by means of an iron-core adjustment a comparatively large coil is necessary, and this is made possible because the stray capacitance across the coil in this circuit is some 6.5 pF.

The output of the r.f. amplifier is taken to the mixer via a π-filter and is injected into a centre-tap on the oscillator coil. This being a "dead" point as far as the oscillator is concerned, very little "pulling" between the r.f. and oscillator circuits takes place. To keep this effect to a minimum the centre-tap should be made very carefully. The use of the π-filter has the great advantage of placing the r.f. output and mixer input capacitances in series, resulting in a total tuning capacitance of about 3 pF.

The r.f. input circuit is untuned as little is to be gained by tuning it. The coil that would be required for this purpose would of necessity have to be very small and no step-up between the aerial and the grid would be possible. In fact, at these frequencies it usually results in a loss. Instead a resistance of 100Ω is used, and this, in conjunction with the valve damping, results in an input impedance of some 80Ω.

One of the greatest difficulties that may arise with a combination such as this, where the receiver remains tuned to the Band I frequency, is to obtain sufficient attenuation of the Band I signal when receiving the Band III signal. To assist this attenuation the filter L_1C_1 is inserted and tuned to the appropriate Band I frequency. In this respect it is necessary to emphasize very strongly that great care must be taken with screening to prevent stray pick-up. The whole of the underside of the chassis must be completely screened, as well as such obvious components as the i.f. transformer and the oscillator coil. Quite apart from the problem of preventing unwanted pick-up of the Band I signal, these precautions are necessary from the point of view of oscillator radiation. Particular attention must be paid to the lead connecting the convertor to the receiver. Good screening, in conjunction with the filter, results in an attenuation ratio better than 40 db.

Being an extremely simple device, there are bound to be occasions when it may prove inadequate, but with a little thought these inadequacies may be overcome. For example, should it be used in an area where it is subject to an exceptionally strong signal from Band I and a rather weak signal from Band III, a further filter can be added in series with L_1C_1, which would increase the attenuation ratio to about 60 db. Alternatively, as the second-channel rejection properties are rather poor greater interference may be experienced from this source than from the Band I signal, and under these conditions it may be more advantageous to have a filter tuned to the image frequency. Similarly, if difficulty is experienced with oscillator radiation, a further filter tuned to the oscillator frequency can be inserted. It is rather too early to assess what sort of conditions will prevail, but it is fairly safe to assume that for the vast majority of cases the convertor should prove adequate as it stands.

There is, however, one other possible cause of interference which should be mentioned here. If the convertor is used with a receiver in which the oscillator radiation is of a high order, it is possible that with an unfortunate combination of circumstances the Band III signal may suffer interference from harmonics of the receiver oscillator. In this event the simplest cure is to detune the receiver and retune the convertor accordingly. This is unfortunate, as it detracts somewhat from the simplicity of operation, but as it is only likely to occur in a few instances it can hardly be said to depreciate the usefulness of the convertor.

Coil Winding Data

L_1	10 turns, 26 s.w.g. enamelled copper wire, close-wound on Neosid former 356/8BA or 358/8BA.
L_2	2½ turns, 18 s.w.g. tinned copper wire wound 8 turns per inch. Former as for L_1.
L_3	5½ turns, 18 s.w.g. tinned copper wire wound 8 turns per inch and centre-tapped. Former (Neosid 5000A) 0.3in diam, 1in min. length.
T_1	Primary: 7½ turns, 26 s.w.g. enamelled copper wire, close-wound. Secondary: 2½ turns, 26 s.w.g. enamelled copper wire, close-wound. Spacing: $\frac{1}{16}$ in. The secondary is wound nearest to h.t. end of primary. Former as for L_3.

For L_3 and T_1 a top plate is required (Neosid 5001) to secure vertical wires to which the coil ends are soldered. A standard can $\frac{13}{16}$in square by 1$\frac{3}{8}$in long will also be required for each former. Iron-dust cores: Neosid 500/500.

Alignment Procedure

A signal generator is unnecessary for aligning the unit if a Band I signal and a Band III signal are available. The procedure is as follows. Connect power supplies to the convertor and its output to the input of the receiver, after disconnecting the Band I aerial from the receiver. Connect the Band I aerial directly to the grid of the r.f. valve (via isolating capacitors if the chassis is live). Increase the contrast control of the receiver, if necessary, to obtain a picture. Then adjust the air-spaced trimmer C_6 for maximum response, readjusting the contrast control as required in order to maintain the signal at about the same level. Transfer the Band I aerial to the convertor input socket and adjust L_1 for minimum signal, again adjusting the contrast control as required. Next disconnect the Band I aerial and replace it with the Band III aerial. Tune in the Band III signal by adjusting the iron core in the oscillator coil and finally adjust L_2 for maximum response. The gain of the convertor is unity, so if the two signals are approximately equal in strength no readjustment of controls will be necessary when changing stations.

A few words about power supplies. The low-tension requirements are 6.3V, 0.6A and the high-tension 180V, 20mA. The unit will operate satisfac-

List of Components

V_1, V_2	Mullard EF80.
C_1, C_5	10 pF ± 10%, N750K Ceramicon.
C_2, C_3, C_4, C_7, C_8, C_9	0.001μF, 350 V, Hunts type W99.
C_6	Air-spaced trimmer, 2-8 pF, Mullard.
C_x	470 pF ± 20%, 1.75-kV working, Erie Isolator Ceramicon type CD9P/101. (Only necessary with "live" chassis.)
R_1	100Ω ± 10%, type RMA9.
R_2	15kΩ ± 20%, type RMA9.
R_3	180Ω ± 10%, type RMA9.
R_4	470Ω ± 20%, type RMA9.
R_5, R_8	2.2kΩ ± 10%, type RMA9.
R_6	2.7kΩ ± 10%, type RMA9.
R_7	22kΩ ± 20%, type RMA9.

torily but with some loss of gain down to 100V h.t., and at this figure the consumption is 10.5mA. It may be an advantage to operate the unit at this lower figure where the signal strength is high and the available power is limited. If the convertor is used in conjunction with an a.c. receiver, that is, one where the chassis is isolated and the heaters are in parallel, it will usually be found that the small amount of power required can be taken from the receiver with little trouble; but when used with the more common a.c./d.c. type of receiver a certain amount of manœuvring may be necessary. The heater chain in the receiver can be broken at some convenient point, and the heaters of the convertor inserted there, after having observed the following precautions. The convertor's heaters must be wired in series. There are usually very good reasons why valve heaters are placed in a certain order, and those which lie closest to chassis potential should on no account be interfered with. Generally speaking, it will be safe to insert the convertor's heaters about half-way along the receiver heater chain. The valves used in the convertor are capable of withstanding 150V between cathode and heater. Lastly, it will be essential to ensure that the current flowing through the convertor's heaters is 0.3A. If the current is not correct resistance shunts will have to be used, either in the convertor or in the receiver. It would be far safer and more practical, however, to provide a separate power supply for the convertor heaters.

Regarding h.t. supplies, it will usually be found that in a.c./d.c. receivers every available milliamp is used and that there is nothing to spare. In that case a small high-tension unit can be built into the convertor. A suggested combination would be a selenium rectifier such as the S.T.C. DRM1, a 16+16μF capacitor for the reservoir and smoothing and a 2.2-kΩ resistor to complete the smoothing.

It should be unnecessary to add that the mains tapping must be adjusted to make up for the extra voltage required. As the unit adds an extra 12.6V to the receiver chain and as the mains tappings are usually arranged in 5- or 10-volt steps, the tappings will have to be placed 10V lower than is usual.

As it stands, changing from Band I to Band III simply involves disconnecting the Band I aerial from the receiver and connecting the converter output in its place. The Band III aerial can be left connected permanently to the convertor. This changing of connections may be considered a nuisance but is probably the safest method. If a switch is used great care will have to be taken against stray pick-up of the Band I signal when using Band III and vice versa. The switch will have to be of high quality: one that will introduce the least possible leakage across the contacts. It will have to be mounted on top of the convertor chassis if the screening precautions are not to be defeated. Coaxial leads to the switch must be used with a minimum of exposed inner conductor.

The wiring of the convertor should, of course, conform to normal v.h.f. practice, with short, straight leads. It is really unnecessary to leave more than ¼in of wire between a component and its connecting point, although it is unwise to reduce it much further as the component may become overheated during soldering. Soldering tags should be mounted close to the valve-holders they are associated with, and must make positive contact to chassis. The unit should be mounted in the receiver cabinet, or on the back as close to the receiver aerial socket as is convenient, and a short lead (coaxial or screened twin-feeder) used for the connection. Do not place the convertor in a position where it would interfere unduly with the receiver ventilation. Neither should it be mounted in a particularly warm area as this might cause trouble due to oscillator drift. In a relatively cool position with reasonable ventilation no trouble has been experienced with oscillator drift after the initial warming-up period of five to ten minutes.

Film on Valve-making

ANYONE who has been round a valve factory will appreciate the difficulties of putting valve manufacturing processes on the cinema screen. One usually leaves with one's head in a whirl, trying hard to remember things from the welter of machinery one has just seen, but not very successfully. This problem of extracting order out of apparent chaos must have been a real headache in the making of the new Mullard educational film "The Manufacture of Radio Valves," for here the whole business is compressed into the space of about 25 minutes.

The part of the film which sticks in the memory best of all is the introductory sequence, showing the individual parts of a valve and how they are assembled by hand, working from the heater outwards. This is all done slowly and deliberately and gives plenty of time for the images to sink in The remainder is taken in the factory, starting with the raw materials and ending with the finished product. Here, however, the presentation is rather less effective, perhaps because the individual shots are not quite long enough—their average length being about five seconds. With such a rapid succession of different images of whirling and reciprocating machinery, one tends to become hypnotized and to lose sight of what is really happening. It might have been better to have selected just a few of the more important processes and given more time to them, filling in the details with the spoken commentary.

The film was made by National Screen Services and is available to technical colleges, schools and scientific associations from the Mullard Educational Service, Century House, Shaftesbury Avenue, London, W.C.2.

"Band III Television Aerials"

The effective radiated power of the transmitters to give the results shown in Fig. 2 on page 182 in last month's issue is 50 kW. This should have been included among the other relevant data in the left-hand column.

"Grounded Grid" A.F. Amplifier

Possibility of Increased Undistorted Output

By THOMAS RODDAM

THERE is a peculiar difficulty which confronts the writer when he embarks on an article about cathode input valve amplifiers: the term grounded grid is almost universally used for this circuit arrangement* and the inverted amplifier seems to be a purely English name for a high-level version. Against this general acceptance of the more familiar "grounded grid," however, we must set the general prejudice against the use of "ground" instead of "earth." Between the Anglophiles and the Americophages the path is narrow; fortunately my shoulders are broad, broad enough to withstand even the whips of comment on this confusion of metaphors, and I propose to write "grounded grid" throughout this article.

I have not checked through the literature, but so far as my memory goes the grounded-grid amplifier was first introduced for use in medium-power broadcast transmitters. A typical arrangement was this: the broadcaster would start operations with a 2-kW "packaged" transmitter, and as his finances improved would add first a 10-kW grounded-grid package, and then a 30-kW grounded-grid package. Obviously this mode of operation was not a normal Western European one, but it suited, and still suits, the conditions in North and South America very well.

During the war the problem of receiver noise began to get the attention it deserves, and a new use appeared for the grounded-grid amplifier. When, in order to obtain a required range in radar, transmitter powers start approaching the megawatt order, even one decibel at the receiver becomes of critical importance, and amplifier circuits like the cascode find their application.

Special Case

The purpose of this article is to describe a much more pedestrian use of the grounded-grid circuit. It arose from one of those highly artificial problems which appear in some fields of telecommunications: I required to obtain the maximum possible output from one triode of a 12AT7 operating at 130 volts. The supply voltage will tell many readers at once that the equipment was to operate from telephone repeater station batteries. The restriction of valve type was to enable a piece of equipment to be designed using a single type throughout, so that the number of spare valves held in stock could be kept down. The power which can be taken out from a 12AT7 operated under normal Class A conditions with 130 volt supplies is about 25 mW, which was insufficient for the application in question. In a desperate search after more power the grounded-grid circuit was tried, and it was found that the available output power could be raised to more than 100 mW. With the addition of local positive feedback a circuit which seems to have great potentialities was obtained. But let us start at the beginning.

The basic circuit of the grounded-grid amplifier is shown in Fig. 1(a). The input is applied between cathode and grid, and the output is taken between anode and grid. The grid is earthed. This description of the circuit, which follows the circuit diagram, is obviously nonsense, because the valve cannot possibly deliver any energy across the grid-anode terminal pair. The circuit has therefore been rearranged slightly, in Fig. 1(b), to show that the actual arrangement is a series one, the input, the anode-cathode path of the valve and the load being all in series. Rearranging again, in Fig. 1(c), we can get a rather different view of the circuit. Perhaps the sooner we go to the equivalent circuit the better.

Fig. 2 shows the equivalent circuit, consisting of the generator e with internal impedance R_1, connected to the valve of parameters μ, ρ and the load R_2. Round the loop there is a current i, which must satisfy the equation

$$e - \mu e_g = i\,(R_1 + \rho + R_2)$$

The grid-cathode voltage, e_g, is given by the equation

$$e_g = iR_1 - e \quad \text{so that}$$

$$e\,(1 + \mu) = i\,[\,(1 + \mu)\,R_1 + \rho + R_2]$$

The output voltage is equal to iR_2, so that the voltage amplification of the circuit is

$$\frac{iR_2}{e} = \frac{(1 + \mu)\,R_2}{\rho + R_2 + (1 + \mu)\,R_1}$$

It is instructive to compare this expression with the corresponding form for the conventional grounded-cathode amplifier, with a resistance R_1 in the cathode lead:

$$m = \frac{\mu R_2}{\rho + R_2 + (1 + \mu)\,R_1}$$

The only difference is that the grounded-grid stage contains the term $(1 + \mu)$ instead of μ in the numerator. It is not quite the same as if the valve had a $\mu' = (1 + \mu)$ because the term $(1 + \mu)\,R_1$ is not altered.

The impedance seen by the load is, as can easily be calculated, $\rho + (1 + \mu)\,R_1$ but although mathematically this is exactly the form found for the usual grounded-cathode valve, R_1 has a rather special meaning in the grounded-grid stage: it is the source impedance of the input generator, which means that it depends on the previous valve in the circuit.

At low frequencies we never bother about the input impedance of a normal valve amplifier, because the resistance needed to provide the grid bias connection determines the input loading. Matters are very different in the grounded-grid amplifier. Facing

* In *Wireless World* it is generally called "earthed grid"—Ed.

the generator we have a load which is obviously equal to e/i and $\frac{e}{i} = R_1 + \frac{\rho + R_2}{1 + \mu}$

The R_1 term is the impedance of the generator itself, so that the input impedance of the grounded-grid valve circuit is

$$\frac{\rho + R_2}{1 + \mu}$$

In a typical circuit, R_2 will be somewhere between ρ and 2ρ so that the order of magnitude of R_{in} can be seen by taking

$$R_2 = 1.5\rho \quad \text{and then}$$

$$R_{in} = \frac{2.5\rho}{1 + \mu} \simeq \frac{2.5}{g_{in}}$$

and for a valve with $g_{in} = 5$ mA/v, $R_{in} = 500$ ohms.

Here we see the limitation of the grounded-grid stage: instead of the relatively high input impedance of an ordinary grounded-cathode valve, we must produce the grid swing voltage across a rather small resistance. To get some idea of the orders of magnitude involved let us take as the approximate valve parameters $\mu = 50$ and $\rho = 10{,}000$ ohms, with a load resistance $R_2 = 15{,}000$ ohms. As we have seen, the input impedance is then 500 ohms. For full drive we shall need about 2 volts, which means that the power fed in at the cathode is 8 mW. This 2-volt input will produce a current through the loop of 4 mA, so that the power in the anode load will be $4^2 \times 15 = 240$ mW. The power gain is only 30 times, or 14.8 db. The most immediate consequence of this result is that the preceding stage must be designed as a power amplifier rather than as a voltage amplifier.

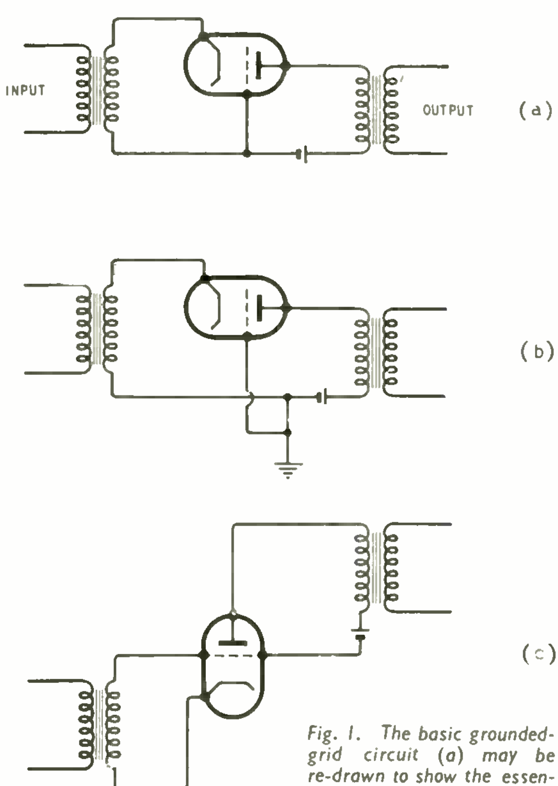


Fig. 1. The basic grounded-grid circuit (a) may be re-drawn to show the essential single loop (b) or to obscure the circuit (c).

It is natural to ask why this relatively low-gain stage should be used at all: we can get very much more amplification from this particular valve by operating it in a conventional way. When we examine the valve characteristics, however, we find that provided the resistance in the grid circuit is low enough we can work a 12AT7 triode up to about $e_g = +3$ volts with excellent linearity. We can hardly get a lower grid resistance than by a direct earth connection, so that in a grounded-grid stage we can operate with very little standing bias and drive the valve across a very much larger part of the anode-current, anode-voltage characteristic. The low anode voltage which was one of the design conditions makes it certain that the anode dissipation will not be exceeded: the limitations are emission and grid heating. Subject to these limitations, the triode will give the sort of efficiency we usually associate with a pentode.

Grid Current Loading

In the circuit as shown, the grid current must be supplied by the signal source, as is usual in valve amplifiers, and the extra grid current loading is a cause of distortion. This changing input impedance distortion is one which we encounter in transistor circuits, too. Some reduction in the distortion from this cause, and other material advantages, can be obtained by using positive feedback. If we feed energy back from the output to the grid circuit the grid current loading is imposed on the output side, where more power is available, and the fractional loading is less. The use of feedback in the grounded-grid stage present one very interesting feature: there is

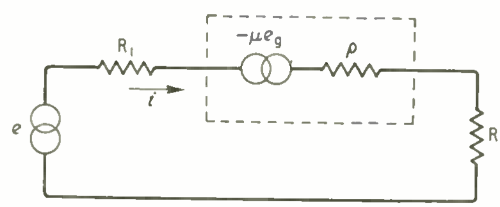


Fig. 2. The equivalent circuit is extremely simple.

complete separation of the input circuit and the feedback loop, until grid current flows.

Let us go back to the basic equation:

$$e - \mu e_g = i(R_1 + \rho + R_2)$$

and now let us add to the normal value of e_g a fraction of the anode voltage, kiR_2 so that we now have

$$e_g = iR_1 - e + kiR_2$$

from which

$$e(1 + \mu) = i[(1 + \mu)R_1 + \rho + (1 + \mu)kR_2]$$

This equation leads us to the following results, which need not be derived in detail:

$$\text{voltage amplification} \left(\frac{iR_2}{e}\right) = \frac{(1 + \mu)R_2}{(1 + \mu)R_1 + \rho + (1 + \mu k)R_2},$$

$$\text{input impedance} = \frac{\rho}{1 + \mu} + \frac{1 + \mu k}{1 + \mu} R_2,$$

$$\text{output impedance} = \frac{(1 + \mu)R_1 + \rho}{1 + \mu k}$$

If the feedback fraction k is zero, these results

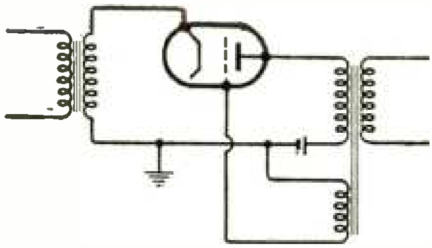


Fig. 3. To apply feedback, an additional winding is provided on the output transformer.

reduce to those which were obtained earlier, as we might expect. Positive values of k will reduce the gain, increase the input impedance and reduce the output impedance, as we should expect for negative voltage feedback. Our concern here is with positive feedback, for which we must consider negative values of k. In the region $|k| < \frac{1}{\mu}$ the term $1 + \mu k$ is still positive, but is becoming smaller as we apply more feedback. The voltage amplification and the output impedance will both rise, while the input impedance falls. At the particular value $k = -1/\mu$, $1 + \mu k = 0$ and the output impedance will become infinite, the input impedance will be $\rho/(1 + \mu)$ while the voltage amplification will be $(1 + \mu)R_2/[(1 + \mu)R_1 + \rho]$. When we put in the typical numbers, the input impedance is seen to be about 200 ohms instead of 500 ohms : the voltage amplification must be considered rather more carefully, because the change in input impedance means that the generator must be matched to a different load. We can see, however, that to drive the original 4½ mA into the loop we now need only 0.8 volts, so that the power delivered to the cathode has been reduced to 3.2 mW and the power gain is 240/3.2 = 75, or 18.8 db.

One of the important features of this analysis is the advantage gained by working in terms of the loop current. Although I have given the voltage amplification expression above, it is a rather awkward concept, because if we try to use it we must introduce the generator impedance, and this means that we must allow for the negative feedback produced by this impedance, which is in the cathode circuit. The grounded-grid amplifier is essentially a power amplifier operating by virtue of the impedance level change introduced in a loop carrying a single current. It resembles therefore a grounded (earthed) -base transistor circuit with a transistor having unity alpha. Clearly, then, the power gain is simply the ratio of load impedance to input impedance, or

power gain $= \dfrac{(1 + \mu)R_2}{\rho + (1 + \mu k)R_2}$ which reduces to $g_m R_2$ approximately when $k = -1/\mu$. This agrees with the result already obtained :

power gain $= 15{,}000 \times 5 \times 10^{-3} = 75$.

As the amount of positive feedback is increased further the power gain continues to rise smoothly until $k = -\dfrac{1}{\mu}\left(\dfrac{\rho}{R_2} + 1\right)$ when it becomes infinite. This, of course, means that the circuit delivers an output in the absence of any input : the amplifier has become an oscillator. The input impedance has been decreasing with the increased feedback, but this critical value corresponds to zero input impedance. The output impedance, which reached infinity for $k = -1/\mu$, jumps sharply to minus infinity for $k = -\left(\dfrac{1}{\mu} + \delta\right)$ where δ is a small quantity, and then remains negative, although increasing (i.e., tending towards zero) as the feedback is increased.

The actual circuit arrangements needed to provide this positive feedback are shown in Fig. 3. An additional winding is provided on the output transformer and this is connected in series with the grid lead, providing either negative or positive feedback according to the sense of connection. The step-down of $\mu : 1$ in this transformer means that the grid winding will have relatively few turns, so that the direct-current resistance will be small and will not cause any appreciable grid-current biasing.

As always when positive feedback is used, it will be essential to provide negative feedback round several stages, which in our particular case means the two stages we obtain from a single envelope using a double triode. The low input impedance of the grounded-grid stage forces us to an intervalve transformer, so that we shall only avoid a very tricky feedback amplifier design if we take the feedback from the anode of the grounded-grid stage : to take it from the output winding would mean two transformers in tandem in the loop, a serious complication. This negative feedback will reduce the output impedance, of course, which may prove important in some applications where regulation or load matching is needed.

This outline of a particular grounded-grid problem is intended to act as a guide for the design of a more advanced amplifier. I have in mind as a typical application the construction of a high-power, grounded-grid amplifier to be tacked on after an existing unit, the conversion of, say, a 3-watt audio amplifier to a 20-watt system. Quite a different application of the theory is found in the negative impedance convertor, a very simple device which can be connected in series with a line to provide amplification in both directions impartially.

"Television Receiver Servicing"

SERVICING technicians are having a hard job nowadays keeping up with television circuit techniques, which grow in complexity with every new model. To help them find their way through this proliferous jungle of circuitry, a new book is being published for *Wireless and Electrical Trader* in two volumes. This is "Television Receiver Servicing" by E. A. W. Spreadbury, M.Brit.I.R.E., the Technical Editor.

The first volume, on time bases and their associated circuitry, has now appeared, while volume two, on receiver and power supply circuits, is still in preparation. The book is not a catalogue of known faults and their remedies, but aims to familiarize the reader with the various sections of the television receiver and the waveforms associated with them. At the same time there are quite a few references to the circuitry of particular models as practical examples.

Volume one begins simply with a chapter headed "Symptom: Blank Screen" then works its way through time bases, sync separators, synchronization techniques (including flywheel sync), interlacing, h.t. boost, picture shift, e.h.t. and deflection circuits, d.c. restoration and finally the use of test gear. Published by the Trader Publishing Company, it is obtainable from booksellers, price 21s, or direct from the distributors, Iliffe & Sons, at 21s 8d.

160-Metre Transistor Transmitter

Encouraging Results Obtained With Very Low Power and Crystal Control

By A. COCKLE* (G3IEE)

TRANSMITTING radio amateurs were quick to take up the challenge of the transistor, and the first recorded amateur contact using transistor equipment is that of G. M. Rose (K2AH) of New Jersey, just over a year ago[1] when he obtained a range of 25 miles on 144 Mc/s, with a power input of 30 mW on c.w. In this country G3CMH (Yeovil) and G3CAZ (Haslemere) appear to hold the distance record (90 miles) with transistor equipment using 30 mW at a frequency of 3.5 Mc/s[2].

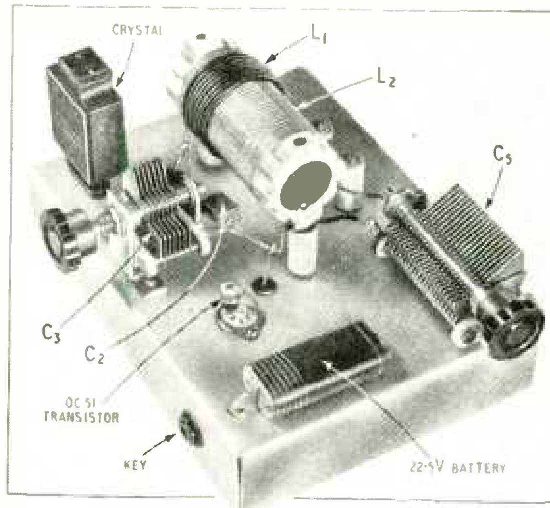
Home construction of transistors has already been successfully achieved, as described by P. B. Helsdon[3] and J. M. Osborne[4]. Now that the 30-shilling transistor is on the market it is anticipated that still more amateurs will be investigating the new techniques.

The details given here are of a transistor transmitter constructed by the writer and which is in constant use on the 160-metre band, mainly for morse code speed practice. It used a Mullard OC50 originally but recent experience has shown that the OC51 gives more consistent results at 1.8 Mc/s, owing, no doubt, to its higher "alpha" cut off†, i.e. 1.5 Mc/s. With the aid of crystal control, a useful output is obtainable up to 3.8 Mc/s although the OC51 is described as an unstable switching transistor.

The circuit employs the well-known negative resistance, base oscillator principle, locked over approximately a kilocycle by a 1.8-Mc/s crystal. With the crystal removed, oscillation is maintained, but the very fine keying characteristics are lost and noise modulation can occur at some frequencies. The value of C_1 is a little critical and should be adjusted for optimum power output. C_3 is adjusted until the oscillation is locked by the crystal and this results in good keying characteristics; by varying C_2 a useful output up to 3.8 Mc/s has been obtained.

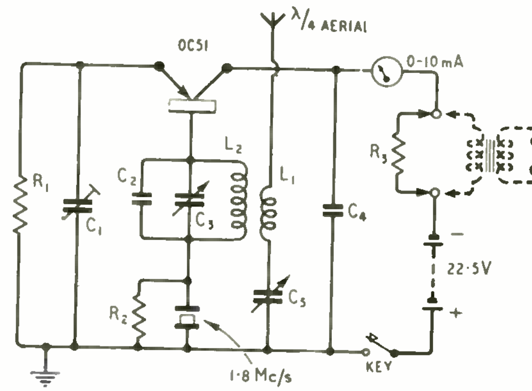
The aerial in use is a ¼-wave horizontal wire loaded against earth; the loading of the aerial is not quite so easy as with higher powers. An absorption wavemeter using a 50-μA indicator is really necessary, but the ex-R.A.F. S.B.A. Visual Indicator, Type 3, already described in this journal[5], is an excellent substitute movement; 30 μA will then give a large deflection.

So far, with this transmitter, results have been very encouraging; on the 1.8-Mc/s band a total of 20 contacts has already been made using between 20 and 100 mW. Reports have ranged from RST599 at 3 miles to RST339 at 30 miles.



The circuit, as shown, has been used as a receiver for local c.w. communications but, in this case, the principle of the oscillating detector is used. With headphones inserted in the collector circuit results were quite encouraging and "break-in" procedure could be adopted.

The author wishes to acknowledge the patient assistance given by R. Penfold (G3DHZ), and V. Brand (G3JNB) of the QPR Society, during the development of the transmitter.



Circuit of the low-power, crystal-controlled transistor transmitter described by the author.

COMPONENT VALUES

R_1	4.7 kΩ ¼ W.
R_2	1 kΩ ¼ W.
R_3	1 kΩ ¼ W (instead of 'phones).
C_1	100 pF (trimmer).
C_2	315 pF (160m Band), 47 pF (80m).
C_3	100 pF (variable)
C_4	1,000 pF.
C_5	350 pF (variable).
L_1	7 turns overwound on L_2.
L_2	32 turns 16 s.w.g. tinned copper, 1½in dia former 2¼in winding length.
OC51, Mullard transistor.	
Crystal, 1.8-Mc/s Band.	

* E.M.I. Engineering Development.

† The frequency at which the current gain is 3 db down.

[1] *QST*, January 1953, p. 53.
[2] *R.S.G.B. Bulletin*, March 1954, p. 409
[3] *Wireless World*, January 1954, p. 20.
[4] *Short Wave Magazine*, March 1954, p. 10.
[5] *Wireless World*, September 1951, p. 376.

Instrument Error Curves

By M. G. SCROGGIE, B.Sc., M.I.E.E.

Presenting Calibration Data in Most Convenient Form

CALIBRATION curves are, at best, a nuisance. Ideally, instruments should have direct-reading scales that are correct. But it is unusual for a direct-reading scale to be as near correct as it could be. The better the quality of the instrument, the more unusual. That may sound paradoxical, but the reason is this; if owing to poor quality the deflection or value of an instrument at any point is liable to vary between somewhat wide limits, then it is relatively easy to provide a direct-reading scale that comes within those limits. A high-precision high-stability instrument, on the other hand, must have a correspondingly precise scale if the full accuracy of the instrument is to be gained without referring to calibration data. It is surprisingly difficult —as anyone who has tried it will testify—to make a scale that does not itself introduce perceptible error.

Considering, then, instruments that have (or could be given) direct-reading scales, there are several reasons why these scales may not conform exactly to the latest and best calibration:

(1) There may be appreciable errors in the drawing or engraving of the scale itself.

(2) Since the scale was made, a later calibration may have revealed appreciable changes.

(3) If a scale is used for more than one range, it is unlikely that it will fit the calibrations of all the ranges perfectly. This is especially true of a.c. meters. On the other hand, one is reluctant to provide a number of separate scales unless the differences in shape are so great that there is no alternative.

In any of these circumstances, one has to choose between tolerating the errors or referring to calibration data. Obviously if full use is to be made of a precise instrument, the latter is the choice, and as stated before it is a nuisance. How much or how little of a nuisance it is depends on the form in which the data are presented; and that is the subject of this note.

Assuming that the instrument is continuously variable (e.g., a voltmeter, or a variable air capacitor) a table of values is perhaps the least convenient of all, for in general it necessitates some system of interpolation, which not only takes time and trouble but introduces considerable risk of mistakes. One therefore tends to think of a calibration curve. The most obvious form of this is a graph of "true values" against scale reading. Fig. 1 is a typical example.

Now although in theory this may seem to do the job, in practice it does it very badly. One has first of all to find the correct point on the "Scale Reading" scale; then to follow this by eye up to the curve, and along to the "True Value" scale; and lastly to convert the position on that scale into figures. Unless this is done carefully and accurately, a greater error may be introduced than one is seeking to correct. Moreover, since the error to be corrected is likely to be a very small fraction of the maximum scale reading, the graph has to be drawn on a large sheet of paper

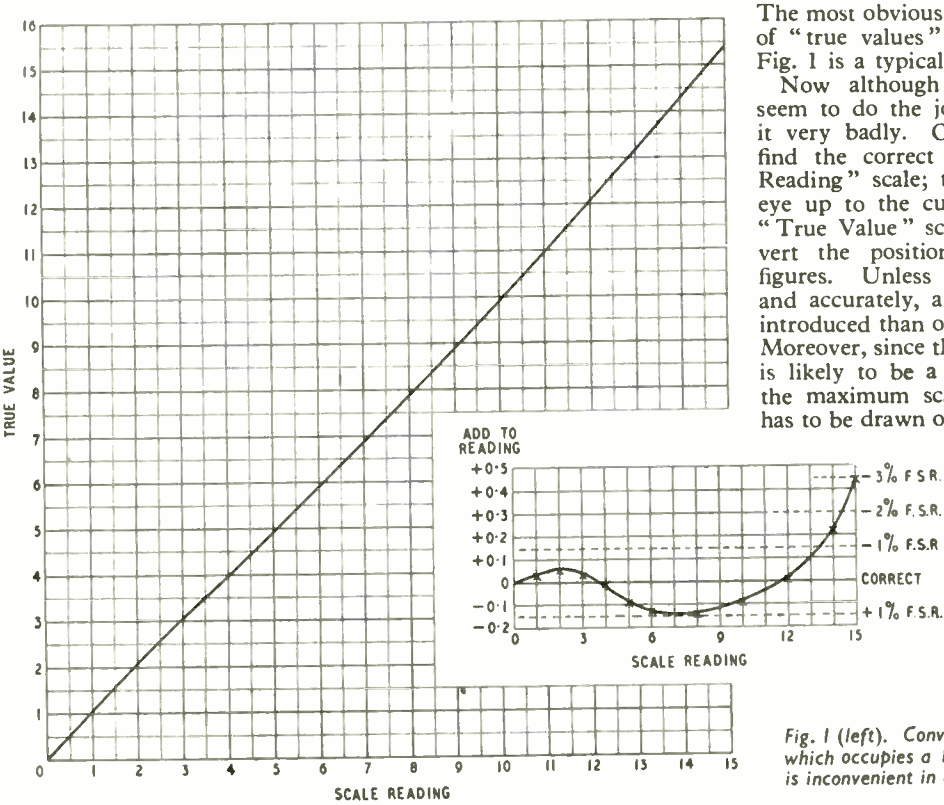


Fig. 2 (inset). More than all the information given in Fig. 1 is here presented more conveniently and precisely in a small fraction of the space.

Fig. 1 (left). Conventional calibration curve, which occupies a large piece of paper and is inconvenient in a number of ways.

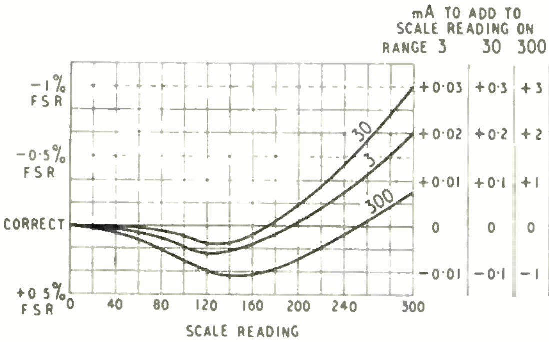


Fig. 3. Example of a correction graph for a multi-range instrument.

for it to show up clearly. This makes the graph inconvenient to use; it cannot be attached to the instrument or kept in a handy small book, and it uses a lot of bench or desk space. The paper is most inefficiently employed, because the only informative part, other than the scales themselves, is in the form of a more or less diagonal line. Most of the paper is not only doing nothing useful, but is actually increasing the risk of error by interposing large eye-confusing distances between the informative zones. These difficulties exist even if a discreet choice has been made of the relationship between the squaring of the graph paper and the divisions of the scale marked on it, and are greatly aggravated by the fiends (thinly disguised as technicians) who perpetrate such horrors as making ten squares represent three scale divisions.

Fig. 2 shows how the same information can be presented more precisely and conveniently in a much smaller space, by plotting only the error against the scale reading. Of course whenever errors are specified it is necessary to make sure that there is no misunderstanding about their sign. Does an error of −0.04 V mean that the true value is 0.04 V less than the scale value, or vice versa? This ambiguity can be completely excluded by marking the error scale "Add to Scale Reading." Then there is no doubt that "− 0.04 V" means subtract 0.04 V from the value read on the instrument scale.

The advantages of this presentation are:

(1) The basic shape of the graph is horizontal instead of diagonal, and so can be accommodated on a relatively small strip of paper.

(2) Despite the reduction in size of paper, the information sought, being of a lower order of magnitude, can be plotted on a much larger scale and so is easier and quicker to read.

(3) The horizontal scale too can be reduced in size, because it does not have to be read precisely, since the error does not normally change rapidly with scale reading. Often a quick glance at the graph shows what correction (if any) is due to be made.

(4) Because of the great reduction in size, combined with removal of the need for close scrutiny, it becomes practicable to have the correction curve in or on most instruments, thus ensuring that it is always available for use.

(5) The form of the error as a function of instrument scale reading is much easier to see, and errors in calibration thereby easier to detect. Calibration points that fall well off a smooth error curve would naturally be suspected until confirmed.

(6) Defined tolerances (such as percentage of full scale reading) can be shown.

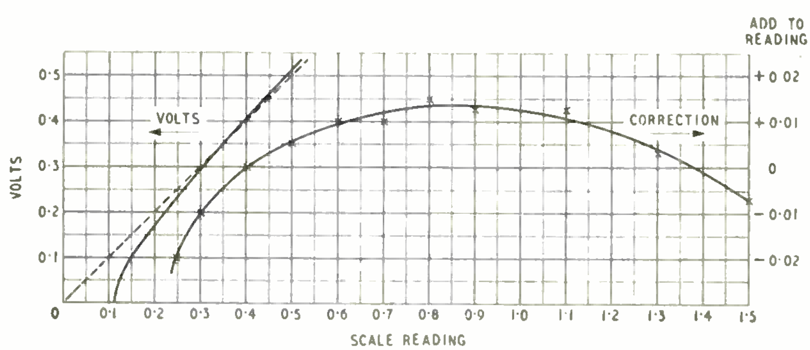
To some workers all this may seem too obvious to need mentioning, but there may be others who have not realized the superiority of the Fig. 2 form over the conventional calibration curve.

It is, of course, possible to plot correction curves for several ranges on one graph, and Fig. 3 shows an example of this. The vertical scales are placed on the right because that is where most of the correcting is required.

Offset Zero Scales

It has been assumed so far that the scale-reading and true-value curves coincide at least at zero. A means of zero adjustment is provided for making this true of most meters, but of course it does not usually apply to scales of such things as frequency, capacitance and attenuation. Nor does it apply to meters in which the zero is deliberately offset to enable all except the curved foot of the calibration to fit a linear scale. An example is the valve voltmeter described in the March 1952 issue, p.93. The lower and most curved part of the scale on every range, except the lowest, can be ignored, because it is covered by the next lower range. But since this cannot apply to the lowest range, which in any case fits the scale least well of any, a slight compromise is advisable if it is desired to use the calibration right down to zero. In this region, the correction actually becomes greater than the true value, and the recommended presentation consequently absurd. Fig. 4 shows an example of a calibration curve taking over from the error curve to meet this exceptional condition, the additional curve being on the left.

Fig. 4. Special case of the lowest range of an a.c. voltmeter having a displaced zero to make all except the lowest part of the calibration fit a linear scale. The unavoidable "bottom bend" is covered by a short calibration curve.



Quartz Crystal Testing

Evaluation of Quality in Frequency Range 50kc/s to 2 Mc/s

By R. ROLLIN*

THE quality of quartz crystal used to be assessed in terms of some oscillator circuit parameter, the value of which was dependent on circuit conditions and component stability. During recent years, however, many manufacturers and users of quartz crystals have become accustomed to a new method of assessing their quality for use as oscillators and filters. This method makes use of a variable "loss" element which is substituted for the crystal unit in a suitable oscillator circuit. Accuracy of measurement is therefore almost entirely dependent on the substituted element and is independent of changes in the remainder of the oscillator circuit. The first commercial and service versions of the new test set were suitable for evaluation of crystal quality in the frequency range 1 to 20 Mc/s.

The test set described here uses similar principles but is intended for use in the frequency range 50 kc/s to 2 Mc/s. Its use is specified in Quartz Crystal Specification RCS.271. Before proceeding with a description of the working principles and design it is interesting to tabulate the main features of the new set in comparison with those of the earlier, higher-frequency, tester. (See Table.)

In the case of the higher-frequency model it was possible to use a simple single valve oscillator of an aperiodic type in which the effective negative resistance is largely independent of frequency over the range for which the test set is used. This is made possible by the comparatively small magnitude of spurious responses close to the operating frequency occurring in high frequency quartz plates. In the case of lower frequency quartz plates, however, it is common for spurious responses of relatively large magnitude to be present at frequencies remote from the fundamental response but still within the frequency range of the test set. Of necessity therefore, the circuit arrangements in this set are different from its lower-frequency companion in that simple selective tuning is employed to ensure operation at the correct frequency. In other respects the new tester is equally simple to use and gives a direct reading of equivalent parallel resistance without calculation or reference to charts.

General Description:— The complete test set may be regarded as comprising the following items:

(1) a special two-valve oscillator circuit with band switching and input capacitance switching;

(2) a calibrated variable impedance substitution element;

(3) an amplitude measuring valve voltmeter;

(4) a meter overload prevention device;

(5) power supplies.

A simplified schematic diagram of the instrument is shown in Fig. 1. Frequency range switching, input capacitance switching, details of amplitude measuring circuit and power supply circuits have been omitted for simplicity.

Operation of the circuit may be understood by supposing a voltage to be applied at the terminals marked "X." Neglecting for the moment the presence of resistor R_1, the voltage across the primary of T_1 will be substantially equal to and in phase with

TABLE

Comparison between the two models

Frequency Range	1 Mc/s to 20 Mc/s	50 kc/s to 2 Mc/s
Range of E.P.R. (equivalent parallel resistance)	4 to 130 kΩ	30 to 600 kΩ
Available input capacitances	20, 30 and 50 pF	30, 50 and 100 pF
Weight	24 lb	40 lb
Height	5½ in	8¾ in
Width	19 in	19 in
Depth	8½ in	11in
Power requirement ..	35 watts	50 watts

* Salford Electrical Instruments.

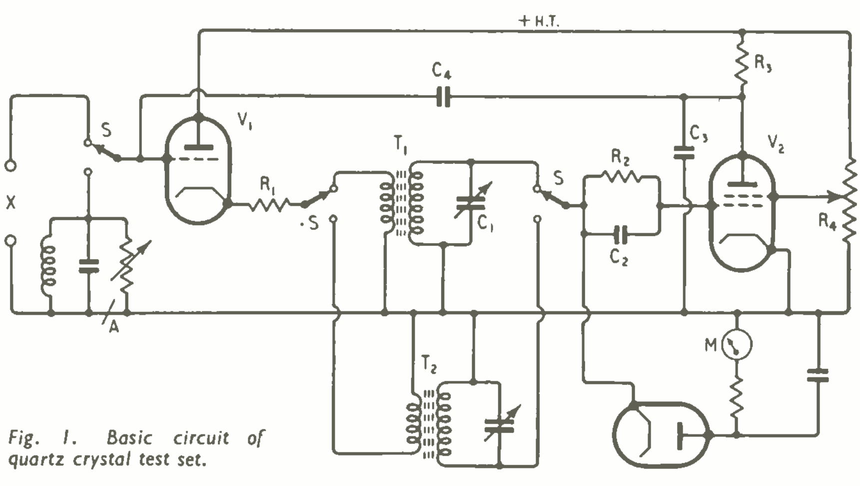


Fig. 1. Basic circuit of quartz crystal test set.

that at the terminals X. The transformer windings are arranged so that the secondary voltage of T_1 is in anti-phase with that of the primary and this voltage appears at the grid of V_2 via the grid leak and condenser R_2, C_2. The anode of V_2 has a capacitance anode load C_3 and the small feedback capacitor C_1 passes some of the voltage appearing at the anode of V_2 to the grid of V_1. This circuit arrangement presents a negative input conductance across the terminals X which is a function of the step-up ratio of T_1, the mutual conductance of V_2 and the ratio of capacitance C_1/C_2, all of which factors are made independent of frequency in order that this component of negative conductance is practically constant over the frequency range of the set.

Clearly the action of the variable capacitor C_1 across the secondary of transformer T_1 will cause the circuit to oscillate at a selected frequency and this is desirable when using lower frequency quartz crystals. Operation at the resonant frequency of this tuned circuit will be dependent on the dynamic resistance appearing across the terminals X. Under given conditions at X, the amplitude of oscillation will therefore be determined by the variable resistor R_1 which controls the screen voltage of V_2. Changing over the switch S substitutes transformer T_2 for T_1 and replaces the unknown impedance across X by a calibrated internal circuit A of variable impedance. Under these substitution conditions the circuit will operate at a fixed frequency dictated by the internal variable impedance circuit, to which frequency transformer T_2 is permanently tuned.

It is worth noting that under conditions of low amplitude of oscillation when the voltage swing on V_2 anode is small, a change of impedance measuring range may be brought about by changing the value of C_3/C_4 provided that the reactance of these capacities is kept small enough to avoid affecting the anode characteristic linearity, with consequent limiting in V_2.

This point has been taken advantage of in the design of the final tester, where a change of feedback ratio is used to create apparent alteration of about 2 to 1 in the impedance range measured by the internal

Fig. 2. Scale shapes typical of the impedance ranges.

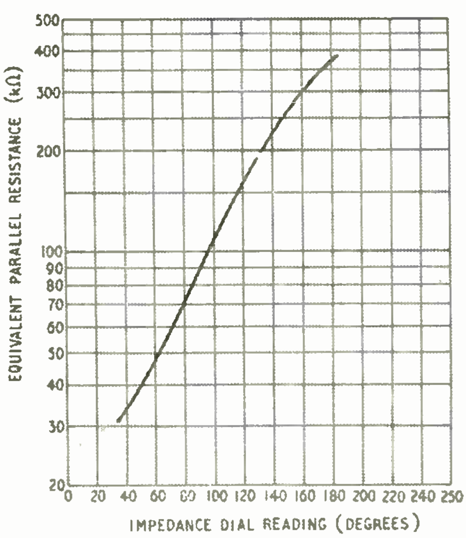


Fig. 3. G.E.C. Quartz Crystal Test Set Type QC166.

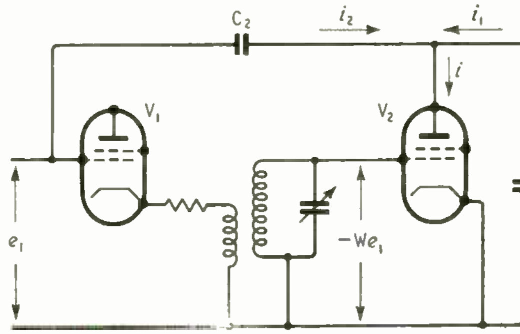


Fig. 4. Simplified circuit for analysing operation of tester.

variable circuit. Thus on frequency bands 1, 2 and 3 covering 50 to 800 kc/s, the impedance range is approximately 47 to 650 kΩ and on frequency band 4 covering 800 to 2,000 kc/s, it is approximately 30 to 370 kΩ. Fig. 2 shows a typical scale shape of the impedance ranges.

Method of Operation:—Figure 3 shows the control panel of the test set. Operation is extremely simple. The crystal under test is plugged in and one of the three input capacitances available (30, 50 or 100 pF) is selected. The frequency range on which the crystal will oscillate is then selected and the frequency tuning control adjusted until the meter gives a peak reading. Next, the amplitude control is adjusted to give a convenient reading; for high equivalent parallel resistance values measurement can be made at any amplitude of oscillation and a suitable setting is 50 mA, whereas with the lowest equivalent parallel resistance values a suitable setting would be 30 mA.

The selector switch is now turned to the "Z" position and the equivalent parallel resistance dial is rotated until the original meter reading, as above, is obtained. Rapid switching between crystal and "Z" will then give an accurate comparison between the two amplitudes of oscillation. Subsequent adjustments to the crystal amplitude are made by the amplitude control, while adjustments to the "Z" amplitude are made by the equivalent parallel resistance control. When the meter gives the same indication for both, the equivalent parallel resistance can be read directly from the equivalent parallel resistance dial. This incorporates two scales: one for crystals operating in the first three frequency ranges, the other for crystals on frequencies of from 800 to 2,000 kc/s.

The test set can also be used for other applications, such as measuring parallel tuned circuits.

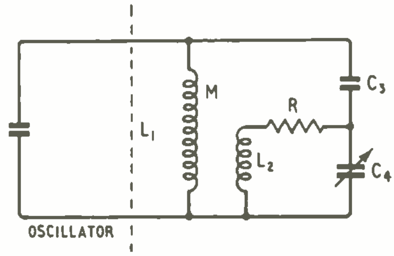


Fig. 5. Basic circuit for calibration.

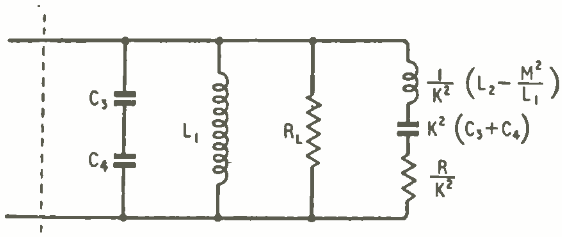


Fig. 6. Theoretical equivalent circuit of calibrator.

Simplified Theory of the Oscillator:—The operation of the oscillator may be analysed by reference to the simplified circuit diagram in Fig. 4.

Let a voltage e_1 be applied to the grid of the first valve. This will result in a voltage of say $-We_1$ at the grid of the second valve, the factor W being introduced to account for the action of the cathode follower stage and the phase changing transformer. This factor will in general be complex, but in the special case of the transformer being tuned to resonance, which is the case corresponding to the setting of the oscillator tuning for a maximum amplitude, W will be real and approximately equal in magnitude to the step-up ratio of the transformer. The voltage and currents at various parts of the circuit are shown in Fig. 4. It is clear that the following relationships for the circuit will hold:—

$$e_1 - i_2/jwC_2 + i_1/jwC_2 = 0 \quad \ldots\ldots(i)$$
$$i - -g_2We_1 = i_1 + i_2 \quad \ldots\ldots\ldots(ii)$$

"g_2" is the mutual conductance of the second valve. The elimination of i_1 using (i) and (ii) gives:—

$$e_1 - i_2/jwC_2 - (g_2We_1 + i_2)/jwC_1 = 0$$

or

$$e_1\left(1 - \frac{g_2W}{jwC_1}\right) = i_2\left(\frac{1}{jwC_1} + \frac{1}{jwC_2}\right)$$

The input admittance "Y" at the grid of the first valve follows thus:—

$$Y = \frac{i_2}{e_1} = \frac{1}{1/jwC_1 + 1/jwC_2} - \frac{g_2W/C_1}{1/C_1 + 1/C_2}$$

This expression gives the input admittance in two parts; the first part of the expression is merely the admittance due to the two capacitors C_1 and C_2 in series, whilst the second part is that due to the oscillator proper. Designating this second component by "Y_0" we have:—

$$Y_0 = \frac{-g_2WC_2}{C_1 + C_2} \quad \ldots\ldots\ldots\ldots(iii)$$

Equation (iii) shows that the oscillator will produce a negative resistance dependent only upon the mutual conductance of the second valve, the ratio of the coupling transformer and the ratio between the load and feedback capacitors.

This simple theory shows that when a number of coupling transformers are used with switching to give a wide range of frequency coverage, the value of "W" must be held constant from band to band and also over the range in each band. Stray capacitance across transformer windings is also of importance but this has been found to remain sufficiently constant when powder cores are used.

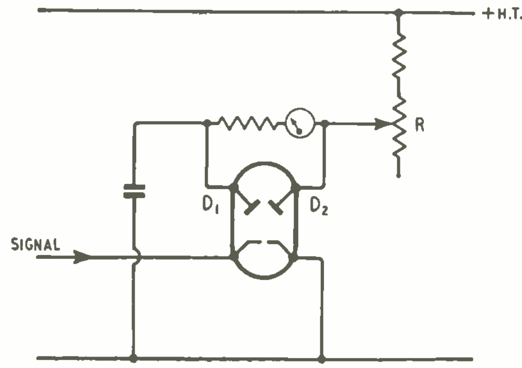
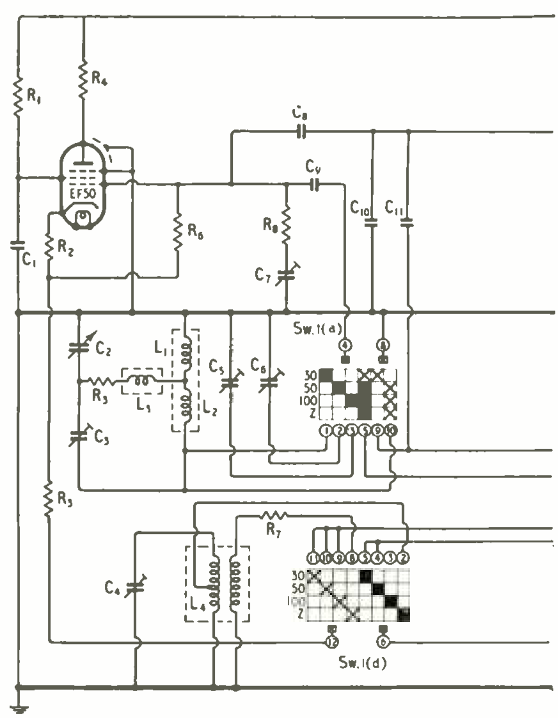


Fig. 7. Overload prevention circuit.

Internal Variable Impedance Circuit:—The basic circuit is illustrated in Fig. 5 and it can be shown that this is equivalent to that in Fig. 6 where K is a factor the value of which is given by:—

$$K = \frac{(L_1 - M)\,M - C_4/C_3}{L_1M \quad (1 + C_4/C_3)}$$

The important consideration in the design of this internal circuit is the resistance range it is desired to cover. The operating frequency must therefore be such that dynamic resistances of the desired magnitudes may be presented by the circuit. For correct design these conditions may be achieved for an operating frequency which is well within the extreme



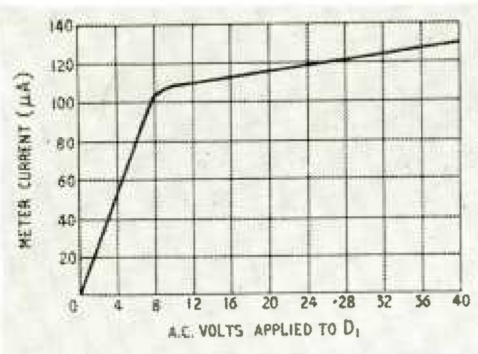


Fig. 8. Characteristic curve of overload prevention circuit.

frequency limits of the instrument. In the final arrangement varying the single component C_4 gives a continuous range of impedance from 30 to 650 kΩ. The other constants in the variable impedance circuit have been chosen so that the operating frequency remains fairly constant throughout at about 300 kc/s.

Meter Overload Prevention:—In changing from a low-impedance crystal to a high-impedance crystal across the input terminals without adjusting the gain control, it would be possible to apply a serious overload to the output measuring diode circuit. Consequently a limiting circuit has been employed as shown in Fig. 7. Diode D_2 is connected in series with the meter and is in a conducting condition to the current flowing through it from the h.t. line via the variable resistance R. The current through the diode D_1 will be in reverse direction to the standing current in D_2 and the limiting diode will only conduct so long as the D_1 diode current is less than this standing value. For relatively higher values of voltage at D_1 diode D_2 will be an open circuit and the change of meter current for these higher voltages will be very small. The value of voltage at which limiting takes place is controlled by varying the resistance R. A typical characteristic of the overload limiting circuit is shown in Fig. 8.

Use of the Tester:—It will be clear from the foregoing explanation that the test set provides an unambiguous means of assessing crystal quality, the accuracy and stability of its measurement depending on the minimum number of factors. In practice care has been taken to ensure the maximum stability of the internal variable impedance circuit with the result that long-term and short-term inaccuracies have been reduced to fractional percentages. The ability to measure crystal quality at three different input capacitances, and at a variety of drive levels, is of obvious value to quartz crystal designers and users. A complete circuit of the tester is shown in Fig. 9 and from the accompanying illustration it can be seen that the layout of controls is simple and self-explanatory. A coupling connection is provided giving a small signal for the purpose of frequency measurement and alternative types of crystal sockets are provided.

Reference:—*J.I.E.E.* Volume 93. Part 3. No. 21. January 1946 "The Measurement of Activity of Quartz Crystals."

Acknowledgements:—The Author wishes to acknowledge the original fundamental work carried out on the design of the original tester by Dr. A. J. Biggs and Mr. G. M. Wells, G.E.C. Research Laboratories, Wembley, Middlesex.

British Patents:—597,430 "Improvement in two terminal electrical oscillatory circuits having adjustable dynamic resistance." (G.E.C. and Biggs.) 597,439 "Improvements in electric oscillatory circuits comprising active networks." (G.E.C. and Biggs.)

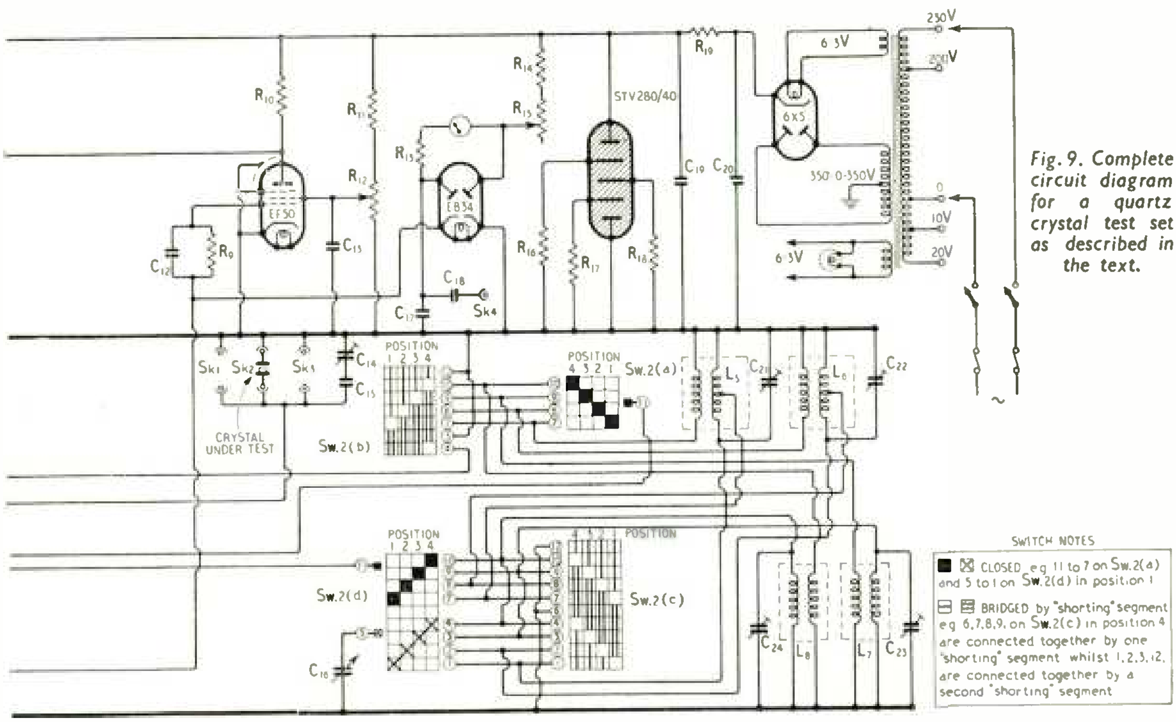


Fig. 9. Complete circuit diagram for a quartz crystal test set as described in the text.

LETTERS TO THE EDITOR

The Editor does not necessarily endorse the opinions expressed by his correspondents

"*Midget Sensitive T.R.F. Receiver*"

I WAS very interested in the design of J. L. Osbourne's receiver described in your April issue. I think he does well to point out the limitation to the stable stage gain of an r.f. amplifier caused by anode-grid capacitance; this is a point which tends to be overlooked.

I am surprised, however, that he did not mention the diode which is built into the envelope of the 6F33 valve. The diode anode is internally bonded to the suppressor grid and has the very desirable effect of preventing the suppressor-grid potential from rising appreciably above the cathode potential. If, due to adjustment of the a.g.c. control, the suppressor-grid potential tends to rise above that of the cathode, the diode conducts and its resistance falls to a value very low compared with that of the resistor (1.5MΩ) connecting the suppressor grid to V2 anode, thus effectively stabilizing the potential of the suppressor grid near that of the cathode. The diode does not affect a.g.c., however, because its impedance becomes infinite when the suppressor-grid potential is driven negative with respect to the cathode.

The "Sensitive T.R.F. Receiver" described in the issue for November, 1951, does not include such a diode and, if the suppressor-grid potential appreciably exceeds that of the cathode, electrons may arrive at the suppressor grid with sufficient velocity to cause secondary emission. The secondary electrons are collected by the screen grid and the anode and if, as often happens, the number of secondary electrons released exceeds the number of primary electrons received from the cathode, the suppressor-grid potential rises. This rise accentuates secondary emission and further accelerates the rise in suppressor-grid potential which ultimately reaches h.t. positive value; this process is similar to that by which the target in television camera tubes is stabilized at the potential of the electron-gun cathode or second anode. The rise in suppressor-grid potential can occur only in circuits such as this in which the external suppressor-grid circuit is of high resistance and normal conditions can be restored by applying a short-circuit between suppressor grid and cathode. The diode in the 6F33 applies such a short-circuit automatically when the suppressor-grid potential tends to go positive with respect to the cathode and prevents the potential from rising. Although with careful adjustment of the "Sensitive T.R.F. Receiver" this rise in suppressor-grid potential can be avoided, the inclusion of a diode would prevent it completely.

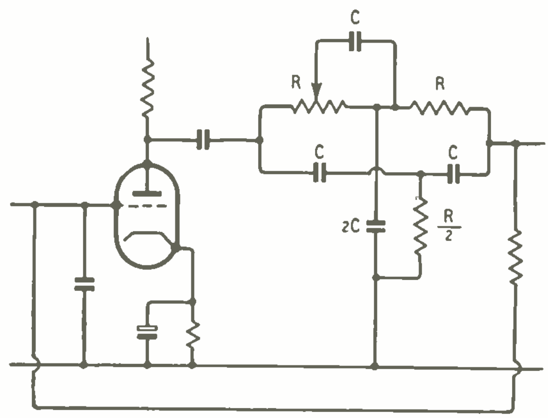
With a diode in circuit the a.g.c. control can be set to make V2 anode a few volts positive with respect to V1 cathode. This is desirable for two reasons. First, it delays the a.g.c., permitting use of the full sensitivity of the receiver on weak signals. Secondly, it permits the anode potential of V2 to "wander" by a few volts without effect on the receiver performance. Such "wandering" may result from a number of causes but perhaps the most obvious is variation in the mains voltage.

Kenton, Middx. S. W. AMOS.

Williamson Tone Compensating Unit

IN reply to John J. Clark's enquiry (April issue, p. 177) concerning tone compensation, I would point out the modification he suggests, whilst providing means of adjusting the equalizing characteristic, would also considerably alter the gain of the amplifier.

In a good design the equalizing control should affect the gain only at those frequencies at which compensation is necessary. It will be observed that, in the circuit in which Mr. Clark is interested, in order to vary the operating frequency of the parallel T filter alternative values of the capacitive elements are selected by means of a switch. A similar result might have been achieved at a somewhat smaller cost by switching alternative values of the resistive elements, except for the fact that the gain of the amplifier would vary with each switch position.



A means of realizing Mr. Clark's objective is to replace one of the "R" components of the filter with a potentiometer of equivalent value and a capacitor of value "C," where at the critical frequency X_c equals R.

It is, perhaps, an unnecessary elaboration to gang-switch this additional capacitor so that its value might equal C at each switch position. Ample variation of the equalizing characteristic should be possible using a capacitor of 150 pF, assuming the remaining circuit values to be those shown in the original circuit diagram.

Bridgnorth, Salop. C. ROBINSON.

"*Plug and Socketry*"

AN "*n*-pole free (male moulding) socket"
Means hard work for storemen who stock it;
Why not use the word "sug"
For a "fixed (female) plug,"
And call a free socket a "plocket"?

M. F. R.

Baby Alarms

THE usually prophetic vision of that seer, "Free Grid," seems to have been subject to a local fade-out in the region of baby alarms. The type in which the microphonic signals received from the infant are reproduced on the TV screen as mere visual interference is, of course, quite outmoded, owing to the inability of even the contemporary mother to interpret them accurately, the result being a fruitless visit to the fridge instead of to the airing cupboard (or *vice versa*). In the preferred type of alarm the sounds proceeding from the cot are analysed by suitable filter circuits and, according to their character, actuate one of several relays controlling the outputs from monoscope tubes, so that the appropriate caption is superimposed on the TV picture. Suitable instructions are thereby conveyed in verbal terms which the most obtuse baby-sitter cannot fail to understand.

An optional accessory records the messages delivered in this way during an evening.

Incidentally, "Free Grid" misquotes the Bard: "puling" is a mere synonym for "mewling"; the word is "puking," which, as the dictionary indicates, is a very different kettle of fish.

"CATHODE RAY."

Ignition Interference

THE experiences of T. A. Dineen in South Africa (your January issue) does not agree with mine. There is a very high percentage of cars on these roads equipped with "all wave" receivers, at least 50 per cent being British, and I can definitely state that no more trouble is experienced in suppressing them than the modern American car. Also, I would like to know the basis for Mr. Dineen's statement that "the average British small car produces . . . . ten times as much interference as practically any American car."

Westonaria,
Transvaal, S. Africa.

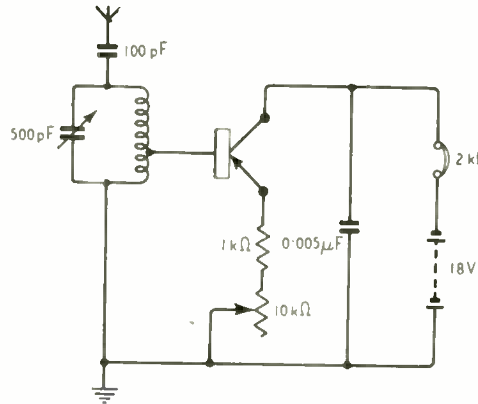
D. J. BRUYNS.

Single-Transistor R 1—7

THE receiver described by W. Grey Walter and Karl Walter, on p. 127 of your March issue would seem to be unnecessarily complex in that it has two tuned circuits. A simpler arrangement which I have found quite satisfactory is given in the accompanying diagram.

Positive feedback is obtained by having an earthed-emitter circuit. The tap on the coil is about one-quarter of the way up and is selected to give approximately the desired amount of feedback. The variable resistor in the emitter then serves as a reaction control.

A 1-kΩ safety resistor is included in the emitter lead and this, together with the headphone resistance, is ample to prevent any excessive currents being passed. One point to note with this circuit is that it gives r.f. feedback without adding any a.f. or d.c. feedback.



Using a Mullard 0C51 point-contact transistor, this circuit will give good results over the entire m.w. band.

Letchworth, Herts.

LORIN KNIGHT.

Un-Decoupled?

IN your issue for April, 1954, on page 171, Fig. 5 bears the words "By decoupling the screen to the cathode." This is, surely, the limit of technician's slang: how can you *de*couple something *to*?

May I suggest "By connecting the screen decoupling condenser (*sic*) to the cathode. . . ."?

London, S.W.19.

L. BAINBRIDGE-BELL.

New Television Camera Tube

Improved Image Orthicon Giving Better Picture Quality

THE improvement of television pictures is in the main a gradual process of development in all links of the chain. At times, however, there occur more marked steps and one of these is the introduction of a new image orthicon camera tube by the English Electric Valve Company. Having an overall diameter of 4½in compared with the 3in of the earlier model,* the tube has roughly three times the target area and as a result is capable of much higher resolution.

The resolution is claimed to be adequate for the French 819-line television system and it can, therefore, easily meet 625- and 525-line requirements. At first sight, therefore, it would seem that the tube would be of unnecessarily high performance for British 405-line television. There is, however, an indirect benefit to be gained from the increased resolution. The new tube will give full resolution on 405 lines with little or no high-frequency compensation; as a result, a higher signal-to-noise ratio can be obtained. Further advantages claimed for the tube are better rendering of grey tones and a reduction of halo, edge effect and ghosts.

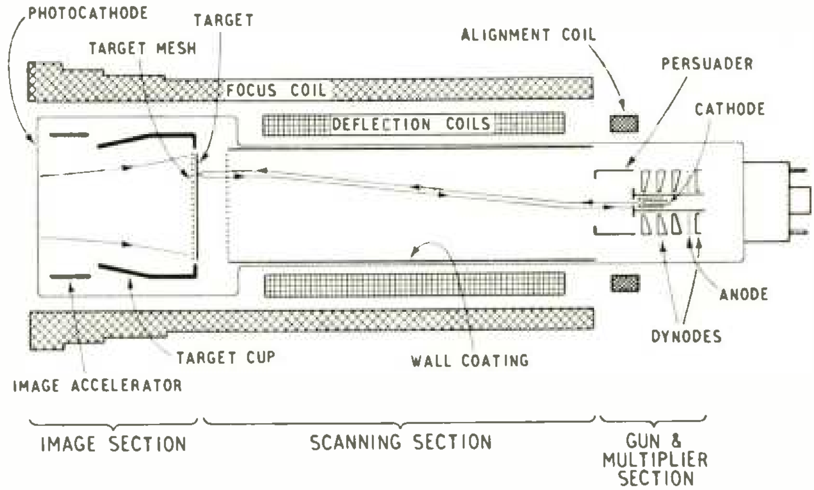
In its basic operating principle the new image orthicon is much the same as the earlier English Electric 3-in tube. The main difference is in the use of a larger target with a working area three times as big as

English Electric 4½in image orthicon camera tube.

* *Wireless World*, May, 1950, p. 162.

the present one. This means, in the first place, that the scanning beam is smaller in relation to the size of the target charge pattern, so that the resolution is increased. Secondly, the increase of area results in the mesh of the target being relatively finer. Both these things mean improved definition. Furthermore, the use of a larger target gives an increase of storage capacitance, and this, in turn, improves the signal-to-noise ratio, which becomes about 6 db better than with the older tube.

As an outcome of this greater signal-to-noise ratio it will be possible to obtain a more pleasing gradation of grey tones. The gamma of the tube, representing the light-input/signal-output relationship, is claimed to be unity, and it will now be possible to reduce this electrically to a value which will offset the high gamma of the receiving c.r. tube.



Simplified diagram showing the main features of the new 4½-in English Electric image orthicon.

Normally, an increase in the size of the target would call for a corresponding increase in the size of the photo-cathode, and as a result larger and more expensive lenses would have to be used to form the optical image. This has been avoided in the new tube by keeping the photo-cathode the same size as before and putting an electron-optical magnifying lens between it and the target. The spread-out of the photo-electron pattern from the photo-cathode is actually achieved by a combination of electrostatic and electromagnetic fields.

In order to introduce this magnification (a three-fold increase in area) it has been necessary to make the image section of the tube somewhat longer than before. An incidental advantage of this is that the photo-electrons from the photo-cathode now perform two complete spirals under the influence of the focusing coil instead of coming to a focus at the end of the first one. As a result "ghosts" or displaced duplicate images, due to secondary emission, are eliminated from the picture.

The final sealing-in of the tube with rotating gas flames.

Commercial Literature

Vulcanized Fibre and other insulating materials. An illustrated brochure giving physical and electrical characteristics and forms in which it is available, from the Anglo-American Vulcanized Fibre Company, Cayton Works, Bath Street, London, E.C.1.

Moulded Connector Blocks, up to 12-way and in current ratings up to 60 amps. Leaflet from Precision Components (Barnet), 13, Byng Road, Barnet, Herts.

German Radio Catalogue of components, accessories, tools, test gear, etc., from Walter Arlt Radio Verband, Karl-Marx-Strasse, 27, Berlin-Neukölln 1; price one mark.

Television Components for the servicing trade, with details of a transformer rewinding service. Mail order catalogue from Direct TV Replacements, 134-136, Lewisham Way, New Cross, London, S.E.14.

Radio-gramophone with 13¼in elliptical loudspeaker, 7-valve, 4-waveband receiver with push-pull output, and 3-speed auto-changer. Descriptive leaflet of the "Fidelity" Model 1619A from the Gramophone Company, Hayes, Middlesex.

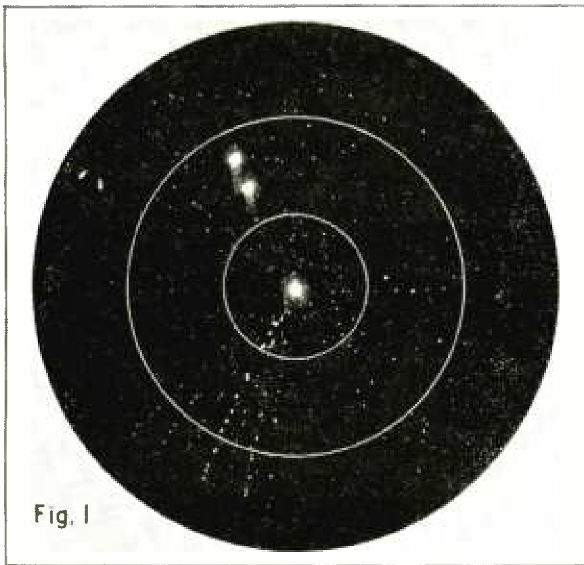
Transportable and Console Tape Recorders made by Kenton Laboratories, 273, Brixton Road, S.W.9, and incorporating the Truvox Mark III tape mechanism, are described in a leaflet issued by Jonathan Fallowfield, 74, Newman Street, London, W.1.

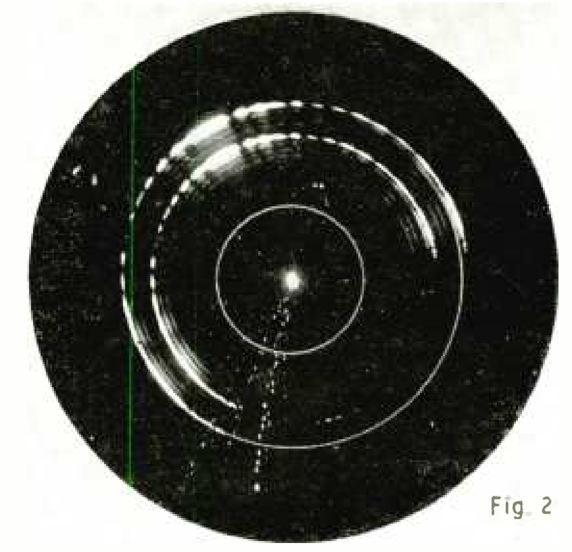
Ohmmeters, direct-reading, wide-range. Four models: 0.001Ω to 6Ω in 6 ranges, 1Ω to 1MΩ in 12 ranges, 1MΩ to 1,000MΩ in 5 ranges and 1Ω to 1,000MΩ in 17 ranges. Leaflet from the Clare Instrument, Co., Rickmansworth, Herts.

Government Surplus: a "Bargains Bulletin" of selected equipment, components and accessories, available from Lyons Radio, 3, Goldhawk Road, Shepherds Bush, London, W.12, on receipt of a 1½d stamp.

Sound Reproduction Equipment: a price list from Grampian Reproducers, Hanworth Trading Estate, Feltham, Middlesex.

American Valves of all makes at lower than normal prices; a brochure describing the sales and service organization of State Labs, 649, Broadway, New York 12, N.Y., U.S.A.





Secondary Surveillance Radar

As an Aid to Air Traffic Control at Civil Airports

By D. A. LEVELL,* B.Sc., Grad.I.E.E.

PRIMARY radar has, since the war, been extensively applied as an aid to air traffic control at large civil airports. At many of these airports the amount of air traffic handled has progressively increased during the past few years, which has resulted in continual changes of the operational requirements for the radar equipments. Some air traffic control authorities now consider that the order of coverage required for terminal area and long range radars is 60 and 150 nautical miles respectively on all types of aircraft at all altitudes up to 50,000 feet. The performance of current primary surveillance radars falls considerably short of this requirement, and it will probably be some time before a simple and reliable primary surveillance radar of the required performance is available. The required coverage can be more easily achieved by a secondary surveillance radar system for which the aircraft carries a transponder that automatically retransmits the radar signals received at the aircraft. The transponder reply may be made at a response frequency which differs from the interrogation frequency so that the response may be easily distinguished from primary radar reflections. The secondary radar display will then be free from ground clutter and cloud reflections which degrade the performance of some types of primary radars.

Primary radar alone does not provide sufficient information to identify the replies from a particular aircraft on the display without the need to request special manœuvres. Auxiliary aids such as VHF/DF and radio beacons have been used to assist identification, but ambiguity is possible when several aircraft are located within the same sector of the plan position indicator. Secondary radar can considerably simplify the problem of identification by means of coding the reply from the transponder. In the simplest case, in response to a request on the radio-telephone, the secondary radar replies from an aircraft can be modified in a way that is distinctly visible on the display. The primary and secondary radar replies of an associated system may be displayed on the same plan position indicator, so that the secondary radar reply overlaps the primary radar reply. A simple means of coding the secondary radar reply is to transmit an additional pulse from the transponder at a predetermined interval after the normal reply pulse. The coding pulse will then appear on the display at the same bearing as the normal reply but at a longer range corresponding to the additional delay (see Fig. 1).

Primary radar alone has been used to determine the heights of aircraft, but equipments at present available

* A. C. Cossor Ltd.

Fig. 1. Typical secondary radar coded responses from an aircraft. The two-pulse reply spaced 45 μsec. shows some after-glow from preceding traces. Sidelobe suppression is used. Range markings have been emphasized.

Fig. 2. Responses from same aircraft as in Fig. 1, but without sidelobe suppression. Range has increased slightly.

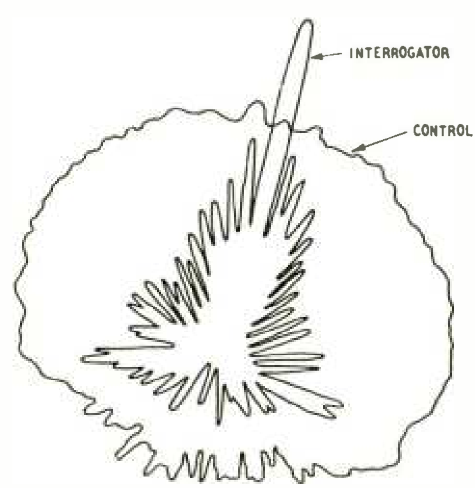
are not sufficiently accurate and flexible for air traffic control purposes. Secondary radar could be used to report the readings of the aircraft altimeter to the ground station by means of suitable coding of the transponder replies. Several methods of applying height coding have been proposed, but the extra airborne equipment required is relatively complex.

The main disadvantage of secondary surveillance radar is that every aircraft to be detected has to carry a transponder. It is a matter of economics to decide if the service provided by secondary radar justifies the cost of installation, maintenance and carriage of these transponders. It is economically desirable that an aircraft equipped with a transponder can use it without modification with ground equipments which are located in several different countries. This means that international agreement must be reached on a suitable system, and many discussions on secondary surveillance radar have already taken place at meetings of the International Civil Aviation Organisation (I.C.A.O.) and the International Air Transport Association (I.A.T.A.).

Early secondary surveillance radar systems developed in the United Kingdom and the United States used existing primary surveillance radars as interrogators. Such systems were satisfactory providing that only one primary radar was used as an interrogator but, when universal application was considered, problems arose such as sidelobe suppression, transponder saturation and aerial polarisation. Some of the solutions investigated for these problems gave rise to further problems and increased complexity of the airborne and ground equipments. More satisfactory solutions to these problems have proved to be possible when a separate ground transmitter is used for the secondary radar interrogation. The operating conditions of the secondary radar system can then be chosen for optimum secondary radar performance.

Sidelobe Suppression—The signal amplitude received by an airborne aerial varies with the aspect of the aircraft. Experience has shown that at L-band frequencies (1,000 to 1,500 Mc/s) the polar pattern is liable to vary as much as 16 db throughout the normal operational conditions for a typical aerial mounted on an aircraft at the lowest point in flight.

In order to ensure a guaranteed range of 60 nautical miles it is necessary to design for sufficient transmitter power to be available to produce this range performance when the aircraft presents an unfavourable attitude to the ground station. This means that an aircraft in a favourable attitude can reply to an interrogation at a range of 380 nautical miles, provided that it is high enough to remain within radio line of sight to the ground aerial. At a range of 38 nautical miles sidelobes of the ground aerial, which are 20 db down on the main lobe, are then capable of interrogating an aircraft which is in a favourable attitude. Similarly sidelobes which are 40 db down produce interrogations at a range of 3.8 nautical miles. The major sidelobes of a typical practical aerial are some 20 db below the main lobe and the average sidelobe level is some 30 db below the main lobe. It follows, then, that sidelobe responses are seen at ranges less than 38 nautical miles, and they may be confused with the responses from other aircraft. At a range of



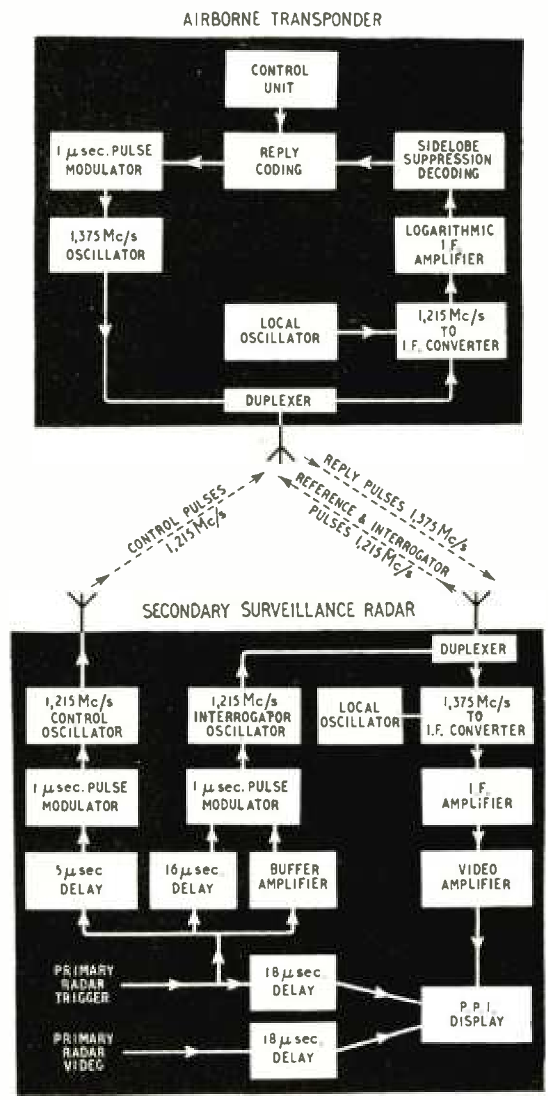


Fig. 3. Horizontal polar pattern of ground aerial system showing interrogator beam and omni-directional control signals.

Fig. 4. Block diagram of Cossor Type I secondary surveillance radar.

3.8 nautical miles there are so many sidelobe responses present that an almost solid ring is seen, and it is impossible to determine the bearing of the aircraft (see Fig. 2).

It is possible to prevent sidelobe responses from appearing on the display by suitable suppression on the responsor channel. A simple means of providing such suppression is to vary the sensitivity of the ground receiver with time, so that at short ranges the sensitivity of the receiver is reduced and only responses received on the main lobe of the receiving aerial are displayed. At first sight this method seems very attractive, but in practice there are many disadvantages. The airborne transmitted power will not be the same from each transponder-equipped aircraft, the signal received will vary with attitude changes of the aircraft, and the signal received will vary with the angle of elevation of the aircraft from the ground aerial. It is not easy to maintain these variables within acceptable limits.

As an alternative, the transponder may be prevented from triggering by sidelobe suppression on the interregate channel. A lower rate of triggering is then required from the transponder so that saturation and interference problems become less acute. The requirement is that in some way the trigger sensitivity of the transponder must be controlled so that at all ranges throughout the required coverage the transponder triggers on signals received on the main lobe only of a rotating directional ground aerial pattern. A suitable sensitivity control signal may be derived at the transponder by integrating the signals received during the whole of one scan of the ground aerial system. This method of suppression has been proved to be satisfactory in practice providing that the aircraft is within the service area of only one ground transmitter at any time. When more than one ground transmission is received, the trigger sensitivity will be set by the strongest of the transmissions received and replies may be prevented to main-lobe signals of the weaker transmissions. The transponder is then said to be captured by the strongest interrogator transmission. This trouble may be overcome by employing a separate ground transmitter to provide a control signal pulse to set the trigger sensitivity of the transponder. This control transmission precedes the interrogator transmission by a short time interval. It is suitably related in power to the interrogator transmission and is radiated on a control aerial which has a horizontal polar pattern such that the field strength of the control transmission exceeds that of the interrogator transmission in all directions other than the direction of the main lobe of the interrogator transmission (see Fig. 3). The transponder circuits store the received control pulse for only sufficient time to allow a comparison to be made between the control pulse and the following associated interrogator pulse. The transponder circuits then recover to full sensitivity.

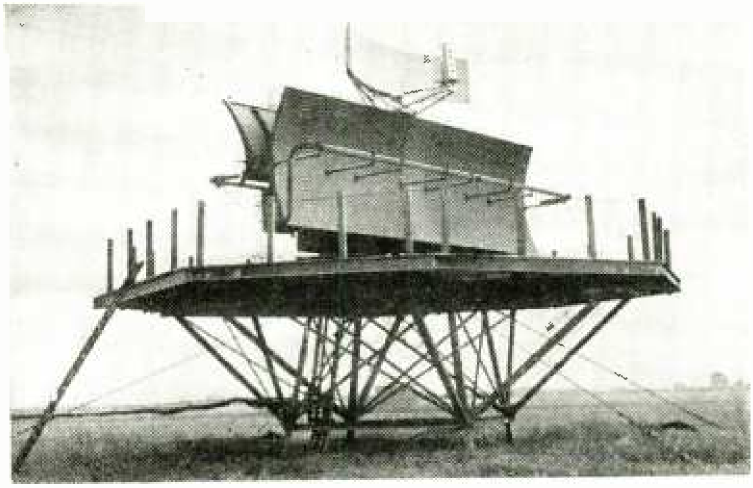


Fig. 5. (Above) Secondary radar scanner mounted on the aerial of an AN CPS-1 primary radar.

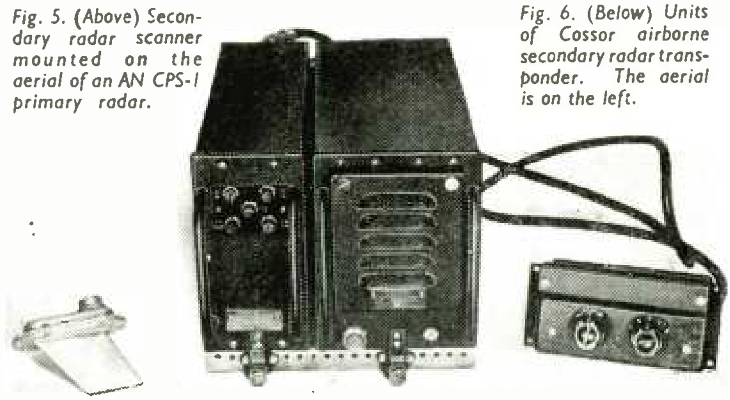


Fig. 6. (Below) Units of Cossor airborne secondary radar transponder. The aerial is on the left.

The time required to perform and recover from each operation may be limited to some 100 μsec. If the average pulse repetition frequency of each ground station is 200 p.p.s. some 10 or more ground stations with random time relationships can obtain almost capture-free service.

An Experimental Secondary Surveillance Radar System.—The Ministry of Transport and Civil Aviation and Cossor's have recently made preliminary trials at London Airport of the Cossor Type I secondary surveillance radar. A block diagram of the system is given in Fig. 4 and the experimental equipment is shown in Figs. 5 and 6. The system employs frequencies in the L band for both the interrogation and response channels; as an interim measure until an international allocation is made the experimental frequencies of 1,215 Mc/s and 1,375 Mc/s were chosen. Three pulse transmissions, each 1 μsec wide, are emitted from the ground equipment for each interrogation of transponders. The first and third of these transmissions are produced by the same oscillator and are emitted on the same directional aerial system. The first is a reference pulse which initiates timed gate circuits in the transponders; the third is an interrogator pulse which passes through the gate circuits to produce interrogation of the transponders. The spacing between the leading edges of the reference and interrogator pulses is 16 μsec. The second transmission is a control pulse emitted 5 μsec after the leading edge of the reference pulse.

The transponder decoding circuits store the amplitude of the control pulse and compare it with the amplitude of the following interrogator pulse. When the received control pulse exceeds the following interrogator pulse by more than 3 db, the interrogator pulse is prevented from passing through the gate. The relative aerial patterns and transmitter powers are arranged so that this condition applies in all directions other than the direction of the main lobe of the interrogator pattern.

The airborne receiver contains a logarithmic amplifier to maintain the decoding characteristic for signal amplitudes up to 50 db greater than the minimum discernible signal. The operating waveforms of the decoder storage and gate circuits are given in Fig. 7.

The block diagram (Fig. 4) shows the secondary surveillance radar associated with a primary radar equipment such as AN/CPS—1 (Microwave Early Warning Radar, often abbreviated to M.E.W.). The reference pulse is emitted at the same time as the primary radar so that the secondary radar replies arrive at the ground station after the primary radar replies. The delay in passing through the transponder is 2 μsec so that the secondary radar replies arrive 18 μsec after the primary radar replies. The primary radar signals are, therefore, delayed by the same amount so that the replies from both radars are coincident on the same display unit. When used with some other types of primary radar equipment it may be simpler to emit the secondary radar reference pulse 18 μsec before the primary radar pulse.

The secondary radar ground aerials and transmitter/receiver equipment were installed on the turntable of the AN/CPS—1 primary radar equipment at London Airport (see Fig. 5). It is possible to similarly mount secondary radar equipment on many other types of primary radar aerial assemblies. This is particularly so since the weight of the secondary radar aerials and equipment can be less than 250 lb. As an alternative the secondary radar can be mounted on its own turntable which can operate either independently or in synchronism with other scanning radar equipment.

An airborne transponder is shown in Fig. 6. The transponder comprises a transmitter receiver unit, a power unit, a junction box, an aerial unit, and a control unit. The equipment units are designed to fit in standard S.B.A.C. racks. The aerial unit is a quarter-wave protruding element which is normally mounted on the aircraft at the lowest point in flight. The control unit is mounted in the cockpit of the aircraft. Alternative forms of power unit are available to suit the aircraft supplies. One form of the equipment will operate from the 19 V ± 1 V supply which is available in many civil aircraft. The equipment draws only 2.6 A from this supply. The total weight of the transponder is 30 lb excluding cables, and it contains a total of 11 valves.

During flight trials a transponder-equipped aircraft was tracked out to a range of 150 nautical miles at an altitude of 20,000 ft. The secondary radar performance was then limited by the radio line of sight.

The following are the major characteristics of the equipment :—

Control and interrogator frequencies	1,215 Mc/s.
Control transmitter peak power	5 kW.
Interrogator transmitter peak power ..	1 kW.
Ground receiver bandwidth	10 Mc/s.
Ground aerial aperture size	12ft × 3ft.
Ground aerial horizontal beamwidth	5°.
Transponder transmitter frequency	1,375 Mc/s.
Transponder transmitter peak power ..	200 W.
Transponder receiver bandwidth	7 Mc/s.
Transponder trigger sensitivity ..	100 db below 1 W.
All r.f. pulse widths	1 μsec.

Transponder reply coding selected manually by a switch on the control unit—

Code 1	Single pulse.
Code 2	2 pulses 15 μsec spacing.
Code 3	3 pulses 15 μsec spacing.
Code 4	4 pulses 15μ sec spacing.

Second-hand Prices

ALLOWANCES for second-hand broadcast and television receivers purchased by radio dealers are tabulated in the booklet "Used Radio and Television Set Values" prepared by the Radio and Television Retailers' Association and issued by the Trader Publishing Company at 2s 9d including postage. The oldest broadcast receivers quoted are a few of 1943 vintage; earlier models than those listed are stated to have no commercial value. In the case of television sets the oldest models quoted are of 1948 manufacture and the value given is based on the need for a new tube to be fitted before a set can be re-sold.

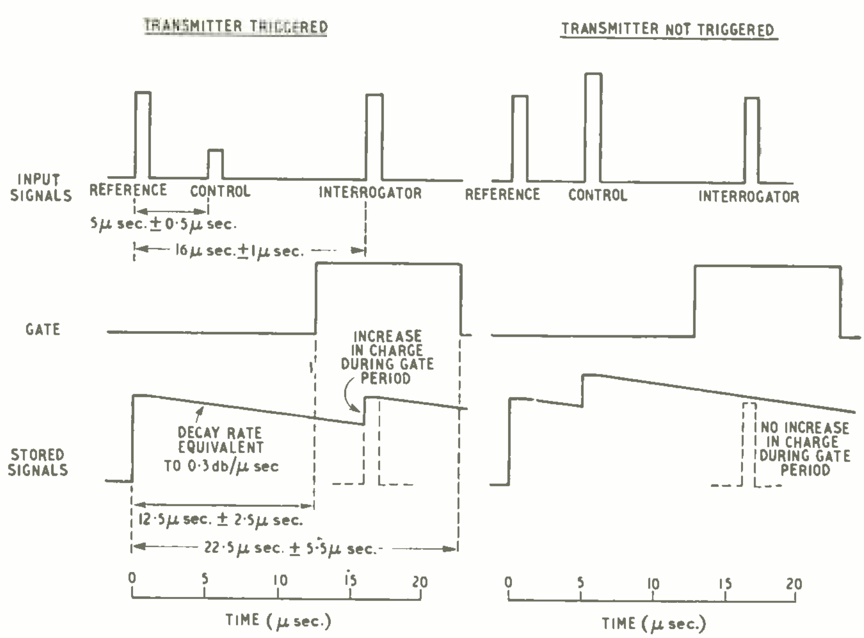


Fig. 7. Waveforms of the decoder-storage and gate circuits.

WORLD OF WIRELESS

Organizational, Personal and Industrial Notes and News

Audio Show

THE SIXTH annual exhibition of sound recording, reproducing and audio frequency equipment, organized by the British Sound Recording Association, will be held at the Waldorf Hotel, Aldwych, London, W.C.2, on May 22nd and 23rd from 10.0 to 6.0 each day. On the preceding day (21st) the annual convention will be held at the Waldorf Hotel at 7.0 when Brian George will give an informal talk, illustrated by recordings from the B.B.C. archives, on "Voices and Sounds from History."

Admission to the exhibition is by catalogue obtainable at the show (price 1s 6d), or by post (1s 8d) from R. W. Lowden, "Wayford," Napoleon Avenue, Farnborough, Hants, after May 8th. A number of the 24 exhibitors listed below will be demonstrating equipment during the show:—

Acoustical Manufacturing; British Ferrograph; Cosmocord; C. T. Chapman; E.M.I.; G.E.C.; Garrard; Goodmans; Grundig; Leak; Leevers Rich; Lowther; Minnesota Mining and Manufacturing; M.S.S.; Mullard; Reproducers (Electronic); Reslosound; Rogers Developments; Simon Sound Service; Sugden; Thermionic Products; Vitavox; Wharfedale; *Wireless World* and *Wireless Engineer*.

It is hoped to include a review of the exhibition in our July issue.

TV Propagation Tests

REFERENCE was made on page 156 of our last issue to the Cologne meeting of the European Broadcasting Union Working Party concerned with v.h.f. and u.h.f. problems. We were, unfortunately, misinformed regarding the non-participation of the U.K.; the meetings were actually held under the chairmanship of E. L. E. Pawley of the B.B.C.

The Working Party intends to organize international propagation tests in Bands IV and V between Western European countries as soon as sufficient equipment is available. It regards the use of these bands for television in Western Europe as a long-term project, and considers that they would probably be found most useful at first to cover areas that cannot be served conveniently by transmitters using Bands I and III.

New Television Stations

CONTRACTS for the masts for the permanent medium-power television stations at Rowridge (Isle of Wight), Pontop Pike (near Newcastle-upon-Tyne) and North Hessary Tor (South Devon) have been placed with British Insulated Callender's Construction Company, and for stations at Divis (Northern Ireland) and Core Hill (near Aberdeen) with J. L. Eve Construction Company. The mast for North Hessary Tor will be 750 feet high and the others 500 feet.

Three-stack super-turnstile arrays have been ordered from Marconi's for the Aberdeen and Northern Ireland stations. They are also providing the vision (5-kW) and sound (2-kW) transmitters for each of the five stations.

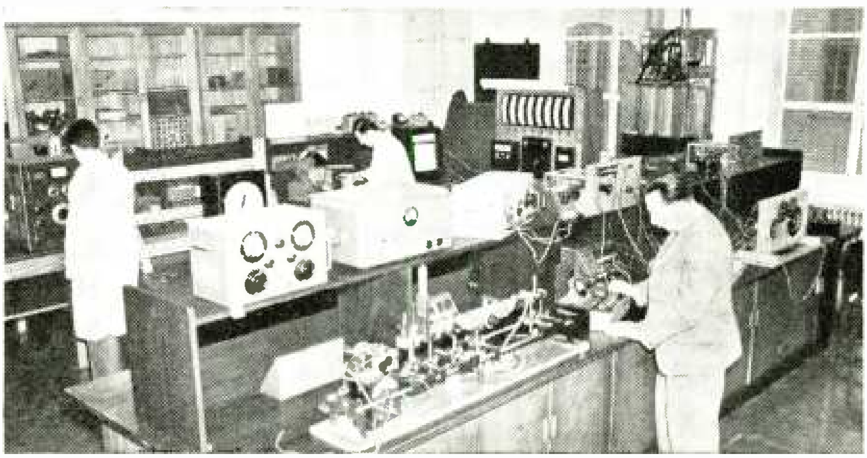
The B.B.C. has also placed a contract with Marconi's for the "design, supply and setting to work" of the main transmission line system at the new London television station at Crystal Palace. This comprises two transmission lines, each of which will feed sound and vision power to half the aerial system. The contract also covers the development and installation of the vision and sound transmitter output combining units and test loads, together with their associated switchgear.

The Corporation is re-equipping some of the existing television studios and has ordered 16 image orthicon camera channels, 6 vision mixers and associated equipment from Marconi's and 17 improved C.P.S. Emitron cameras and ancillary equipment from E.M.I. Sixty-two Pye picture monitors have also been ordered.

International TV Exchange

AN international exchange of television programmes between eight European countries has been arranged for June 6th to July 4th as a result of a recent meeting at Cannes of technical and programme representatives from Belgium, Denmark, France, Germany, Gt. Britain, Holland, Italy and Switzerland. The B.B.C.'s technical representatives were M. J. L. Pulling and T. H. Bridgewater.

BATTERSEA POLYTECHNIC, London, has recently been extended and the new buildings were formally opened by H.R.H. The Princess Royal at the end of March. This Wireless World photograph shows one of the new laboratories of the Electrical Engineering Department. There are three laboratories devoted to light current engineering (telecommunications, measurements and electronics). Some of the equipment came from the Polish University College, which was set up in 1945 for Polish ex-servicemen and is now amalgamated with the Polytechnic.



The arrangements are similar to those made at the time of the Coronation transmissions last year, except that the exchange is two-way and Italy and Switzerland have now to be linked to the network. The two countries will be linked by a relay station 10,000 feet up on the Jungfrau. Standards converters will be installed at Dover (819 or 625 to 405 lines), Breda, Holland (405 to 625 and *vice versa*), Paris (405 to 819 and *vice versa*) and possibly at Baden Baden (819 to 625). Transmissions from this country will be picked up near Calais and relayed by radio links to the converter stations at Paris and Breda for linking into the network of 25 stations on the Continent.

PERSONALITIES

Sir Vincent Z. de Ferranti is the new president of the Television Society in succession to **Sir Robert Renwick,** who has resigned after holding the office for seven years. Sir Robert, who is also president of the Radio and Electronic Component Manufacturers' Federation and the Mobile Radio Users' Association, is a director of the Associated Broadcasting Development Company and High Definition Films, Ltd. He has been elected an Honorary Fellow of the Television Society. Sir Vincent is chairman and managing director of Ferranti, Ltd., and a past president of the I.E.E.

G. M. Wright, C.B.E., B.Eng., M.I.E.E., the retiring engineer-in-chief of Marconi's Wireless Telegraph Company, joined the company in 1912. After service in the first world war, when he was closely associated with the establishment of the naval d.f. network, he returned to the company's Research Department, of which he subsequently became head. During the last war he was seconded to the Admiralty and became chief scientist at the Admiralty Research Establishment. Mr. Wright returned to Marconi's as engineer-in-chief in 1946. He was a member of the Radio Research Board of D.S.I.R. from 1948 to 1950.

Marconi's new engineer-in-chief is **B. N. MacLarty,** O.B.E., M.I.E.E., who has been Mr. Wright's deputy since 1947, when he returned to the company after 21 years' service with the B.B.C. Mr. MacLarty joined the Development Establishment of Marconi's Aeronautical Department at Writtle in 1921, where he worked with Capt. Eckersley and Sir Noel Ashbridge on the experimental broadcasting transmitter 2MT. He was head of the Design and Installation Department when he left the B.B.C.

B. N. MACLARTY.

R. J. KEMP.

R. J. Kemp, who becomes deputy engineer-in-chief, joined Marconi's in 1917 and from 1930 to 1939 was engineer-in-charge of television research. During the war he was responsible for special research for the Air Ministry at the company's Great Baddow Research Station, of which he became chief in 1948.

The new chief of research at Great Baddow in succession to Mr. Kemp is **Dr. E. Eastwood,** M.Sc., M.I.E.E. He joined the English Electric Company in 1946 and took charge of the Radiation Laboratory. Two years later he was transferred to Marconi's as deputy chief of research.

Dr. G. W. Sutton has rejoined the Siemens Brothers Group of Companies as director of research and education. For the past seven years he has been chief superintendent of the Signals Research and Development Establishment of the Ministry of Supply. After the first world war he was appointed lecturer in electrical theory and measurement at the City and Guilds College. From 1930 until 1942 (when he was lent to the Ministry of Aircraft Production) Dr. Sutton was in charge of Siemens general telephone laboratory. For the latter part of the war he was co-ordinator for technical services between the R.A.E. Radio Department, Farnborough, and T.R.E., Malvern.

DR. G. W. SUTTON.

H. W. Forshaw, O.B.E., has succeeded Dr. G. W. Sutton as chief superintendent, S.R.D.E. Since 1947 he has been assistant director in the Directorate of Electronics Research and Development (Defence).

Colonel A. H. Read, C.B., O.B.E., has retired from the post of director of Overseas Telecommunications (G.P.O.) which he has held for the past four years. He was Inspector of Wireless Telegraphy for three years having previously been deputy inspector for fifteen years. With his retirement the Overseas Telecommunications Department has been discontinued. Its work is now shared by the External Telecommunications Executive, of which **W. A. Wolverson** is director, and the Radio and Accommodation Department, of which **R. J. P. Harvey,** C.B., is director. The Radio and Accommodation Department is now responsible for frequency allocations and the issuing of licences for amateurs and business radio.

J. Blears, B.Sc.(Eng.), A.M.I.E.E., recently appointed chief engineer of the Scientific Apparatus Department of Metropolitan-Vickers, joined the company as a special trainee in 1936 and then entered the physics section of the Research Department. During the war he worked on the design of the proximity fuze and on the development of magnetrons for centimetre wavelengths. In 1948 he took charge of the vacuum physics section, becoming responsible for mass spectrometry and for research work on high vacuum apparatus.

Arthur C. Main, B.E., M.I.E.E., until recently director and works manager of Metropolitan-Vickers' Trafford Park Works, has been appointed director of manufacture. After taking his B.E. degree at Adelaide University, he came to Metrovick in 1925 as a college apprentice. In 1935 he was appointed assistant superintendent Switchgear and Control Departments, and three years later the new Radar Department was included in his duties. He was appointed superintendent of the Switchgear, Control and Radio Departments in 1944 and two years ago became works manager and a director of the company.

H. P. White, B.Sc., has been appointed head of the Data and Publications Section of the Mullard Technical Service Department. He has been in the department since 1949 and was previously in the company's Valve and Applications Laboratories for six years. One of his principal responsibilities will be compiling technical data and information on the applications of Mullard valves and tubes for use by manufacturers, servicemen and home constructors.

Harley Carter, who was until recently head of Mullard's Technical Publications Department (now part of the Data and Publications Section), will in future devote his entire time to the Mullard Educational Service which he introduced in 1948. The object of this service is to make available to lecturers, teachers and instructors, material—including films, film strips, wall charts and technical exhibits—for use in teaching the principles and applications of electronics.

OUR AUTHORS

D. A. Levell, who contributes an article on secondary surveillance radar in this issue, received the B.Sc. special degree in physics with first-class honours in 1947 as an external student of London University. He joined the Research Division of A. C. Cossor, Ltd., in 1947, and, after working for a short time on instrument development, transferred to the design and development of airborne radar equipment. Since 1951, Mr. Levell has been the project engineer in charge of a team working on secondary surveillance radar equipment.

John D. Howells, who describes a thyratron invertor in this issue, served a two-year apprenticeship at the Post Office Research Station, Dollis Hill, before joining the Ministry of Supply in 1949. While in the Ministry, he was working mainly on ground radar and navigational aids. Since 1952 he has been doing research and development work for the English Electric Company at Luton.

Irving Gottlieb, author of the article "Decade Counter" on page 234 was a radar technician in the U.S. Navy before he entered the American radio industry. He has been developing electronic circuitry and designing electro-mechanical devices for radar for various manufacturers and has recently held the post of electronic design engineer of the Lynch Carrier Systems Company, of California, U.S.A. He operates an amateur station with the call W6HDM.

IN BRIEF

Broadcast Receiving Licences in the United Kingdom totalled 13,350,136 at the end of February. The month's increase in television licences was 67,380, bringing the total to 3,173,024. Car radio licences totalled 223,509.

R.E.C.M.F. Council.—In addition to the member firms listed in our last issue as forming the Council of the Radio and Electronic Component Manufacturers' Federation for 1954, the following have been co-opted (the representatives' names are in parentheses): Antiference (N. M. Best); Colvern (R. F. Collinson); Morganite Resistors (S. G. Treganza).

Television Premiums.—At the recent dinner of the Television Society, which was attended by some 300 members and guests, awards were given for papers presented during the past year. Recipients and their papers are: D. Birkinshaw, "Importance of the D.C. Component"; D. D. Jones, "Transistors"; Dr. D. McMullan, "Scanning Electron Microscope"; C. J. Hunt and E. W. Elliot, "Sine-Squared Pulse"; C. A. Marshall, "Adaptors for v.h.f. and u.h.f. Television Reception"; and H. A. Fairhurst, "Flywheel Synchronizing." George Clack, who was until recently secretary of the Society, received an award for his field-strength meter for Band III, shown at this year's exhibition.

Automatic Computing.—A summer school in programme design for automatic digital computing machines, similar to those organized in previous years, will be held in the University Mathematical Laboratory at Cambridge from September 13th to 24th. The course will give basic training in the mathematical use of machines, dealing with the processes employed and their embodiment in programmes which specify the operation in detail. A syllabus may be obtained from G. F. Hickson, M.A., secretary of the Board of Extra-Mural Studies, Stuart House, Cambridge.

To mark the fiftieth anniversary of the publication of the first paper on **Oxide-Coated Cathodes** the Société Française des Ingénieurs Techniciens du Vide is organizing an international convention to be held in Paris on June 24th and 25th. Further details are obtainable from the Society, 44, Rue de Rennes, Paris, 6.

Electronic Control Equipment will be featured by a number of exhibitors at the fourth biennial Mechanical Handling Exhibition, which opens at Olympia on June 9th. As in previous years the exhibition is being organized by *Mechanical Handling* and will be open daily (except Sunday) from June 9th to 19th at 10.0 and close at 6.0, except on the 14th and 17th, when it will close at 9.0. Free admission tickets are available from the exhibition manager, Dorset House, Stamford Street, London, S.E.1.

Sound Reproduction.—An audience of over 1,300 attended the lecture-demonstration recently given by G. A. Briggs, of Wharfedale Wireless Works, in St. George's Hall, Bradford, when the Wharfedale corner three-speaker system was used. For the purpose of comparison piano solos were played and were followed by commercial recordings of the same pieces reproduced by the three-speaker system.

Five Service Trophies—one for each of the television areas—are being offered annually by E. K. Cole, Ltd., to dealers participating in a competition organized to encourage "after-sales service."

INDUSTRIAL NEWS

Ardente Acoustic Laboratories announce that they have granted an exclusive licence to manufacture and sell Ardente p.a. equipment, loud hailers and intercom gear to Easco Electrical, Ltd., of 6/8, Brighton Terrace, Brixton, London, S.W.9 (Tel.: Brixton 4961), to whom all enquiries for such equipment should, in future, be addressed. The company's hearing aids will continue to be handled from Ardente's head office, 21, Wigmore Street, London, W.1.

As part of the refit of the 8,056-ton Post Office cable ship *Monarch* preparatory to the laying of the first transatlantic telephone cable, **Marconi Marine** is installing new radio communication equipment.

Hudson Electronic Devices, Ltd., of Appach Road, London, S.W.2, have received a $27,000 order for 100 v.h.f. radio telephones from Mott Electric, Ltd., of Vancouver, Canada. The equipment has been specially developed to meet the Canadian specification for radio telephone gear, which is different from that applying in this country.

Sound amplification systems for nine R.A.F. hospitals are being installed by **E.M.I. Sales and Service.** They provide for dual programme operation with a selector switch and volume control by each bed. E.M.I. is also installing sound-reinforcing equipment in the Great Hall of the Royal College of Surgeons, London.

Maniplastics, Ltd., of Mortgramit Square, Hare Street, London, S.E.18 (Tel.: Woolwich 0885), has been formed for the design and manufacture of machinery for use by the plastics industry, and the manufacture of plastic products. The chief engineer is L. G. H. Cantle, who has been with Applied High Frequency, Ltd., and Creators, Ltd.

Pye, Ltd., of Cambridge, have been awarded a £70,000 contract for radio-telephone equipment to be used on R.A.F. aerodromes under Air Ministry jurisdiction. The two-way v.h.f. equipment will be installed in fire-fighting vehicles, ambulances and control towers.

Dawe Instruments, Ltd., whose factory is at Brentford, Middlesex, have moved their offices from 130 to 99, Uxbridge Road, Ealing, London, W. 5 (Tel.: Ealing 6215).

Decade Counter Feedback Used

By IRVING GOTTLIEB

WITH the type of electronic counter to be described here, it may be said that the desired mode of operation is attained by causing the device to "fool" itself. Its response to stimuli is somewhat analogous to that of a person reacting to an illusory situation. This idea can best be appreciated by supposing that we have been given the job of designing a counter.

In order that the indication may conform to decimal notation, a basic circuit capable of providing two distinct functions is required. First, overall division by a factor of ten must be achieved. Secondly, the dividing process of such a circuit must be such that decade division is obtained, not in one jump, but rather in an orderly sequence of ten stable states, each occurring in a separate part of the circuit. This is necessary in order that a registration for individual counts may be obtained. These requirements call for a frequency dividing technique, but exactly how shall we go about it? A multivibrator can easily be synchronized to perform ten-fold frequency division, but we are faced with a formidable task when we seek points within the circuit to give us our ten discrete modes of stability.

If we wanted to divide by two rather than ten, we would recognize an encouraging feature in the multivibrator. The "scale-of-two" divider delivers a full cycle for every pair of input cycles. Inasmuch as this circuit comprises two valves which alternate in their equilibrium states between conduction and cut-off, it is evident that there are, within the circuits itself, two stable modes of operation. This satisfies the requirement that a unique state exists for each incoming pulse. The only trouble so far is that the circuit behaves as a free-running oscillator. This is fine for frequency halvers, but for counters the circuit must be passive in the absence of incoming pulses. Fortunately, it is not difficult to incorporate some modification to restrict feedback below the point of self-oscillation.

In Fig. 1 is shown a modified form of the well-known Eccles-Jordan circuit. The operation of this circuit, known also as a "binary," will be discussed first. Then we will show how several of these binaries can be connected in cascade in order to achieve a net division of ten.

Suppose that a negative pulse is injected at point A when V_1 is the "off" valve and V_2 is the "on" valve. The anode potential of V_1 is suddenly decreased. (The anode potential of V_2 is practically unaffected because it is held constant by the conduction of V_2.) The resultant negative transient is communicated through C_1 to the grid of V_2. This causes reduction of anode current in V_2 with an accompanying rise in its anode potential. The rapid increase of anode potential of V_2 is transferred through C_2 as a positive pulse to the grid of V_1. As a result V_1 now draws more anode current, with an attendant decrease in its anode voltage. The result of this sequence of events is that the stimulus responsible for the transient condition is reinforced by the response it has evoked. The circuit is in a regenerative state; a rapid switching action ensues, culminating with an exchange of roles between V_1 and V_2. There are, from this sequence, seven important cause and effect relationships associated with the binary. They are as follows:

1. Two negative pulses injected at point A produce one full output cycle.
2. Positive pulses applied to A provoke no disturbance of binary equilibrium.
3. A positive pulse injected at B will always tend to make V_2 the "on" valve.
4. The application of a negative pulse to point B will tend to make V_2 the "off" valve.
5. If a positive pulse is impressed at point C, the tendency will be to make V_1 the "on" valve.
6. If a negative pulse is impressed at C, this will tend to make V_1 the "off" valve.
7. If the grid return of V_2 is momentarily opened, V_2 will be made the "on" valve.

No. 7 is an important mode, for it establishes the so-called "original state" of the binaries, i.e., the condition they must be in before counting commences.

We have considered cascading several binaries in order to achieve overall decade division. Inasmuch as each binary in a cascaded chain divides by two, the total division must be 2^n where n represents the number of such cascaded dividers. At once it is seen that division by eight may be obtained from

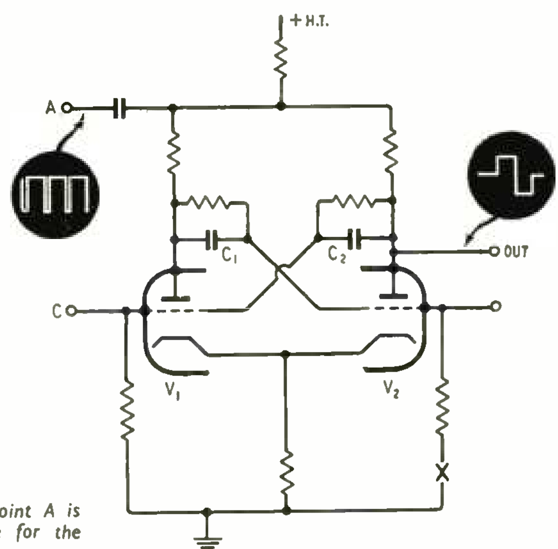


Fig. 1. (Right) Basic circuit of binary counter. Point A is the input of the circuit, while points B and C are for the introduction of feedback pulses.

for Converting Binary to Decade Counting

three stages and that four stages will divide by 16. We cannot resort to fractional stages. How, then, may we accomplish division by ten?

It so happens that four cascaded stages may be arranged (Fig. 2) so that the output of the last stage undergoes one complete cycle of equilibrium change for every group of ten pulses applied to the input of the system. This is brought about by providing feedback paths within the system. Pulses generated when a certain stage is keyed are returned to an earlier stage which cannot distinguish between the returned pulses and the genuine incoming pulses. The net result is that the system "thinks" it has received sixteen counts when only ten have been impressed at the input terminal. How this is accomplished will now be explained.

Operation of the System

Initially, all four binary stages are, or have been caused to be, in their "original" state of equilibrium. Suppose now that four consecutive negative pulses are applied to the input terminal of the system. The first stage will be triggered to produce two negative pulses at its output terminal. In turn, the second stage will generate a single negative pulse. The third stage will be triggered by this single pulse through only a half cycle of equilibrium shift, thereby developing a single positive-going transient at its output terminal. The fourth stage will not be affected, since it can be triggered only by a negative pulse from stage three. So far, the sequence of events conforms to that expected from cascaded binaries. After the third stage has been triggered, however, the operation is considerably modified from that of a chain without feedback.

The feedback path provided by one capacitor returns the positive transient produced by stage three to point C of the second stage. This stage is now re-triggered through a half cycle of operation, generating a single positive output pulse in the process. The progression of events has now reached a dead end because the input terminal, point A of the third stage, is not responsive to positive-going transients.

Consider now the introduction of two additional pulses at the input of the system. As a result of the preceding train of four pulses the first stage has been left in its "original" phase of operation. The second stage has been left in its half-triggered phase, this being likewise true of stage three. The fourth stage is, of course, still in its original operational state.

When the two additional pulses are applied to the system input, the first binary will undergo one complete flip-flop cycle. The negative pulse from this transition will trigger the second stage through the second half of its operational cycle. In turn, the transient generated by the second stage will trigger the third stage through the second half of its operational cycle. This time, a negative pulse will be returned to point C of stage two. Inasmuch as the second stage is already in the phase of equilibrium in which the feedback pulse tends to drive it, no disturbance will be initiated. However, the negative pulse which is delivered from stage three to stage four will trigger the last-mentioned stage through one half of its operational cycle. In this instance a negative pulse will be returned from the fourth stage to point B of stage three. The pulse is negative-going because it has been derived from the "V_1" valve of stage four which has just been triggered to the "on" condition. The third stage will be re-triggered through one half of its operational cycle. In turn, the positive transient generated by the third stage is fed back to point C of the second stage. Having been in its "original" phase prior to this feedback pulse, stage two is now triggered through one half an operating cycle.

Six pulses have thus far been injected at the input

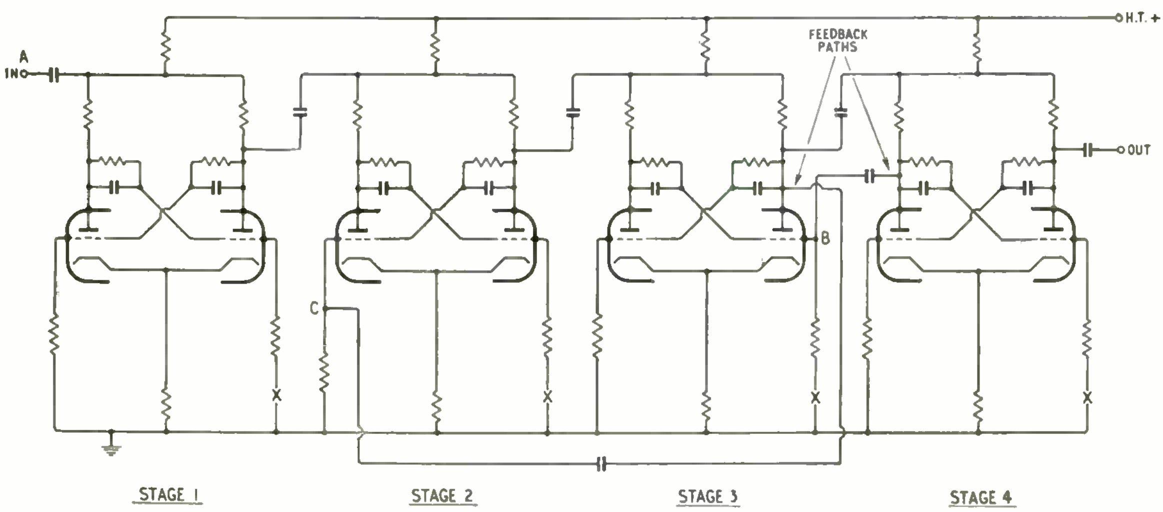


Fig. 2. Complete circuit of decade counter. The two feedback paths cause the four binary stages in cascade to produce ten stable states instead of the sixteen which would occur with no feedback.

Fig. 3. Decade counter of the type described, built as a plug-in unit for use in a commercial instrument.

of the system. The state of equilibrium of each stage is now as follows:

Stage 1—original state (V_1 " off," V_2 " on ").

Stage 2—original state.

Stage 3—half cycle completed (V_1 "on," V_2 "off").

Stage 4—half cycle completed.

By applying four more negative pulses to the system input, we shall have supplied a total of ten pulses. The first stage will generate two negative pulses which, in turn, will cause the production of a single negative pulse at the output of stage two. This negative transient will trigger the third stage through the second half of its operational cycle, again developing a negative transient. Finally, the fourth stage will be triggered in the same fashion. In so far as the fourth stage is concerned, the transients communicated by the two feedback paths will not have produced any further disturbance. Observe now that ten input cycles have resulted in one complete operational cycle being executed by the fourth stage which as a consequence delivers a single negative-going transient.

Thus we have accomplished decade division through a transition of ten unique stable states. By connecting neon lamps at appropriate circuit points and designating them numerically a visual indication of the counts is made possible.

Decade counters themselves may be connected in cascade in order to provide a maximum counting capacity of 10^n where n represents the number of decade counters so arranged. After each decade counter has performed a ten-fold division its " slate is wiped clean " by momentarily opening the grid returns of all " V_2 " valves. As already pointed out, this re-establishes all stages in the original operating phase and the system is ready for the subsequent ten-count. Fig 3 shows a decade counter unit from a commercial instrument. Five such counters are utilized in this particular model, permitting a maximum count of one hundred thousand. The instrument automatically times the duration for which the counters may receive pulses for precise one-second periods. Consequently the indication is in cycles per second.

NEWS FROM THE CLUBS

Basildon.—The recently formed club for employees of the Marconi Wireless Telegraph Company at its new works at Basildon, Essex, has a membership of 35. It is proposed to build a club transmitter, as soon as suitable accommodation has been found, and to start morse classes. The secretary of the Marconi (Basildon) Amateur Radio Club is E. F. Slee.

Cleckheaton.—Dr. G. N. Patchett, who is well known to readers of *Wireless World*, will lecture on colour television to members of the Spen Valley and District Radio and Television Society on May 5th. The meeting will be held at 7.30 at the Bradford Technical College where Dr. Patchett is head of the Electrical Engineering Department. At the club meeting on May 19th at 7.30 at the Temperance Hall, Cleckheaton, A. Thompson (G2FCL) will speak on "144 Mc/s." Sec.: N. Pride, 100, Raikes Lane, Birstall, Near Leeds.

Coventry.—At the next meeting of the Coventry Amateur Radio Society (G2ASF) on May 10th, David Harries (G3RF) will describe a valve voltmeter. Meetings are held at 7.30 on alternate Mondays at 9, Queens Road, Coventry. Sec.: K. Lynes (G3FOH), 142, Shorncliffe Road, Coventry.

Southend.—Among the subjects scheduled for future meetings of the Southend and District Radio Society, which meets at 7.30 on alternate Fridays at the Municipal College, Victoria Circus, Southend, are: " Ferranti Electronic Computer," " Marine Echo Sounding " and " Application of X-Ray to Physics." Sec.: J. H. Barrance, M.B.E., 29, Swanage Road, Southend-on-Sea.

B.A.T.C.—The British Amateur Television Club now has a membership of 300. One of the members, R. L. Royle (G2WJ/T), is regularly transmitting pictures on 436 Mc/s that should easily be received within a radius of 40 miles of Dunmow, Essex. Sec.: M. Barlow (G3CVO), Cheyne Cottage, Dukes Wood Drive, Gerrards Cross, Bucks.

British Two-Call Club.—Membership of the British Two-Call Club, which is open to all British subjects in the Commonwealth who have held call signs in two or more countries, is now 124. Major J. M. Drudge-Coates (DL2RO) has been elected president for 1954 and Major D. A. Macdonnel (G8DK) vice-president. Sec.: G. V. Haylock (G2DHV), 63, Lewisham Hill, London, S.E.13.

I.R.C.M.S.—The Coventry Radio Controlled Models Club has become the Coventry group of the International Radio Controlled Models Society and will continue to meet at 8.0 on the first Wednesday of each month at the Allied Airmen's Services Club, 78, Holyhead Road, Coventry. The I.R.C.M.S. now has five groups; the others being in London, Birmingham, Manchester and on Tyneside. Group Sec.: P. Haselock, 25, Wainbody Avenue, Coventry.

QRP.—New sections have recently been introduced by the QRP Society for members especially interested in low-power v.h.f. transmission and reception, direction finding and t.r.f. reception. Space is devoted in each issue of the Society's monthly duplicated journal, *QRP*, to matters of interest to these and other sections of the Society. Sec.: J. Whitehead, 92, Rydens Avenue, Walton-on-Thames, Surrey.

THYRA RON INVERTER

...o *Watts at 240 V, 50 c/s* ... *Mains*

By J. D. HOWELLS, B.Sc. (Eng.)

...country is now supplied ... mains, there are still ...y available supply is d.c. ...will, no doubt, have found diffi-...ing gear to operate from their mains ... fact, many items, such as automatic record ...gers, are virtually unobtainable for d.c. operation. Quite a usual technique is to use some form of d.c.-a.c. converter, the most common type being the rotary transformer. A second, and less common type is the thyratron inverter, and this is the subject of the present article.

The Thyratron Valve.—The simple thyratron valve is essentially a triode structure in an envelope containing an inert gas (generally argon) at low pressure. The introduction of this small amount of gas so changes the operation of the device that it should no longer be regarded as a "valve" in the electronic sense of the word. In fact, the "equivalent circuit" of a thyratron, shown in Fig. 1(b), consists merely of a switch in series with an e.m.f. of about 16 volts. The action of the grid is only to close the switch, and this can be done only provided the supply voltage, V, is greater than 21 volts.

Once switched on, the anode voltage drop is equal to the e.m.f. of the "equivalent" battery (about 16 volts) and is independent of the magnitude of the anode current. The current through the valve is thus determined only by the values of the supply voltage, V, and the anode resistor, R_L, Fig. 1(c).

We must now look more closely at the switching function of the grid. Referring again to the circuit of Fig. 1(c), let us assume that the grid is first made negative, and then that the anode voltage is applied. Provided the grid is sufficiently negative, the valve will remain "off," and the anode voltage, V_a, will be equal to the supply voltage V. As the grid is made progressively less negative, a point will be reached where the potential is insufficient to keep the valve cut off. The valve then "fires," or "strikes" (corresponding to a closing of the switch of Fig. 1(b)) and V_a falls to 16 volts. The voltage drop across R_L is then (V-16) and the anode current is (V−16) R_L. The grid potential at which the valve fires or "strikes" is termed the "critical grid voltage," V_c, and its value depends upon the initial anode voltage, V_a (= V). It must be pointed out that once conducting, the grid is no longer effective. We cannot cut the valve off again by merely making the grid more negative. The only way in which we can switch off the thyratron is by reducing the anode supply to below 16 volts.

The relation between V_c and V_a may be represented graphically, and a typical curve is shown in Fig. 2. For any values of V_g and V_a which give a point in the shaded region of the graph, the valve will remain non-conducting. If we change V_g so as to approach the curve, the valve remains "off" until we reach the boundary of the shaded area. The valve then strikes, V_a falls to 16 volts, and the graph is no longer applicable.

To illustrate the operation, we can give a numerical example. Let R_L = 1 kΩ and V = 240 volts.

Suppose V_g is set to −12 volts, and then the h.t. supply connected. Since V_a = 240 and V_g = −12 corresponds to point P in the shaded area of Fig. 2,

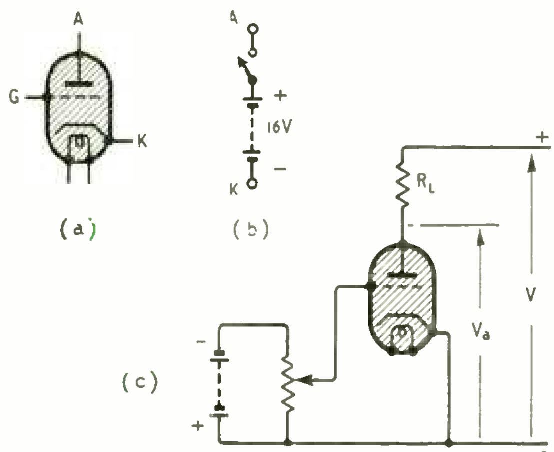


Fig. 1. Thyratron symbol (a), equivalent circuit (b), and basic test circuit (c).

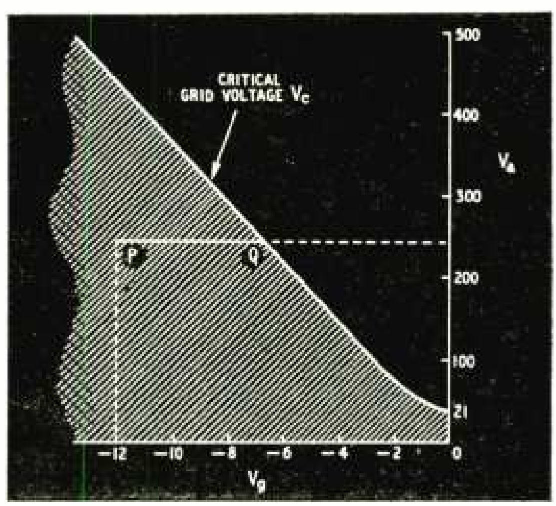


Fig. 2. Typical thyratron control curve.

the valve will not draw any anode current, and V_a remains at 240. If now V_g is reduced, we shall proceed along the line PG in the graph, until we reach point Q. The valve then strikes, and V_a falls to 16, leaving a potential drop of 224 volts across the 1-kΩ load. The anode current thus becomes 0.224 amps, and is independent of any further change in V_g.

The main characteristics of a thyratron may therefore be summarized as follows :—

1. There are two states only, conducting and non-conducting.
2. When conducting, V_a is constant, the current being determined by the anode circuitry.
3. The valve may be changed from the non-conducting to the conducting state (i.e., switched on) by decreasing the negative grid voltage to a critical value.
4. The valve can be switched off only by reducing the anode supply voltage until no anode current flows.

We are now in a position to consider the theory of a thyratron inverter.

Inverter Circuit Theory.—Fig. 3 shows the circuit of a simple inverter. R_{L1} and R_{L2} are the loads (assumed equal ... alternating power is to be ... ing wave is fed, push-pul... grids. Due to a small grid ... will receive a negative charg... equal to the peak value of the s... built up across R_1. Grid stop... limit the peak grid current.

Now, let the anode voltage be app... of one valve, say V1 reaches V_c t... potential, that valve will strike. At ... appear across R_{L1}, and C charges exponen... 224 volts via R_{L2}. Half a cycle later, V_{g2} ... causing V_2 to strike. V_{a2} then falls by 224 ... this voltage drop is communicated to V_{a1} ... This sudden fall in V_{a1} causes V1 to be exting... and C begins to charge in the opposite dire... V1 remains off until its grid potential again rea... V_c, when it strikes, and the cycle is repeated. T... condenser C arranges for the switching off of the valves, and is called the "commutating" condenser.

Fig. 4 shows the grid and anode voltage waveforms

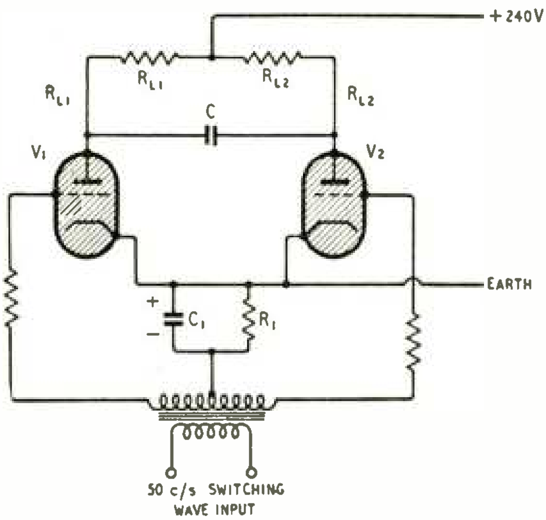


Fig. 3. Circuit arrangement of a simple thyratron inverter.

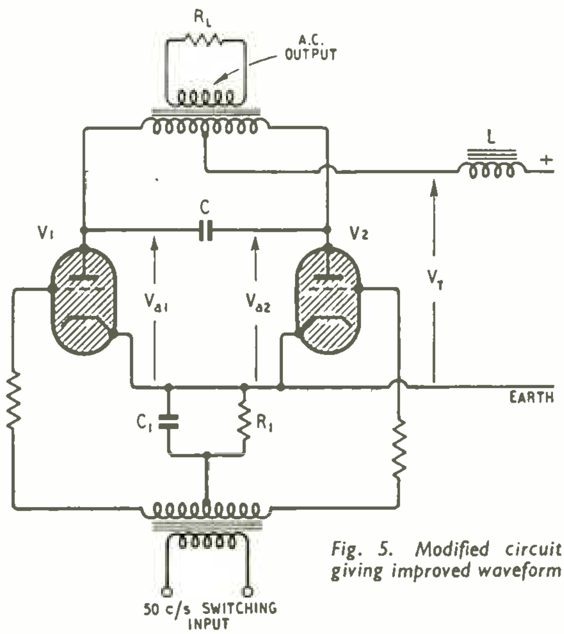
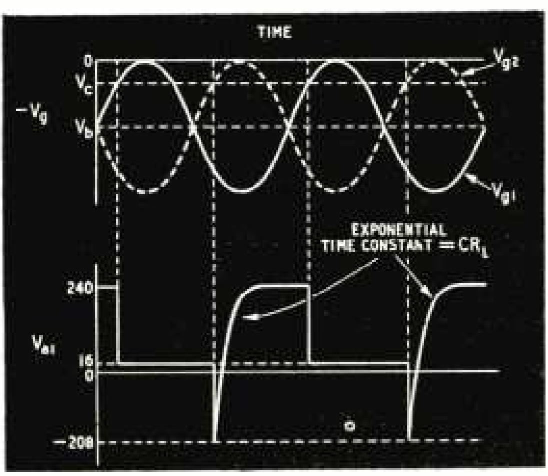


Fig. 5. Modified circuit giving improved waveform

Fig. 4. (below). Waveforms of anode and grid voltage in the circuit of Fig. 3.



of V1. A sine-wave switching voltage is assumed for convenience, V_c is the critical grid voltage for V_a = 240 and V_b is the self-bias voltage appearing across C_1R_1 ($C_1R_1 >> 1/50$).

Thus the currents flowing in the loads R_L are certainly alternating, but the waveform is square and peaky. However, by using the circuit of Fig. 5 this waveform may be turned into something very nearly sinusoidal. To understand fully the working of this circuit (which is a good deal more complicated than would appear) involves a long and difficult mathematical analysis. Since such an analysis is outside the scope of this article, we shall give a word picture of the operation, based on the results of the mathematical treatment.

In the circuit of Fig. 5 we see that here the load is now a single resistance R_L, and is in the secondary circuit of the output transformer, a far more useful arrangement than the previous case. Also, there is an impedance common to both anodes, the choke L.

This is necessary to allow commutation to take place, and also to get rid of the " spike " at the point of commutation.

Referring to the circuit, when a valve strikes, both anodes fall in potential by the same amount, due to coupling by C. Since we have a " push-pull " transformer, clearly the centre tap must fall through the same potential. Thus the commutation spike now appears across the common impedance L, and not across the transformer winding. In the previous example (Fig. 3) we saw that after commutation, C discharged exponentially through R_L. In the circuit of Fig. 5, since the entire commutation voltage appears across L, C now discharges along a curve determined by L and C. Thus the curve, by suitable choice of components, may be made part of a damped sine wave, giving a sine wave voltage across C (i.e., across the transformer primary). It is therefore the values of L and C which determine the waveform of the output, the circuit acting as a resonant circuit, which receives an impulse every half cycle. L and C are chosen such that the frequency at which they cause the circuit to resonate is equal to the frequency of the switching wave.* We should note that the primary inductance of the transformer plays no part in the resonant circuit.

A complete set of waveforms for the circuit is shown in Fig. 6. They show clearly that at each point of commutation both anodes swing negative by the same amount (a) and (b) and all of this swing appears across the choke L. The curve (c) showing the voltage V_T across L is a series of first half cycles of a heavily damped oscillation. These damped half cycles are identical in shape to those appearing across C (the other component of the resonant circuit). Condenser C charges in opposite directions on alternate half cycles, therefore reversing the direction of current flow in the output transformer primary. This inverts the waveform after each commutation, and the resultant output is the near-sinusoid shown in Fig. 6 (d).

To sum up the action, we should regard the thyratrons as feeding current into the resonant circuit LC. The circuit " rings," and the decay current flows through the transformer primary, giving the near-sinusoidal output.

A further point which can be deduced from Fig. 5 is the effect of loading the transformer secondary. It is clear that when power is drawn from the transformer, an effective resistance appears across C. A load therefore reduces the effective circuit Q, and consequently affects the output voltage. We shall therefore expect the inverter to have poor regulation and the waveform to deteriorate slightly as the load is increased. We might add here that bad regulation is about the most serious failing of the inverter.

Practical Circuit.—In the foregoing we have discussed the inverter circuit in principle ; a practical arrangement is shown in Fig. 7. For ease of description the circuit is broken down into three parts, each of these will now be described.

(a) *Thyratron grid circuit.*—Throughout the previous arguments we have assumed a switching wave to be available to drive the thyratrons. The use of a separate oscillator in this design may surprise some

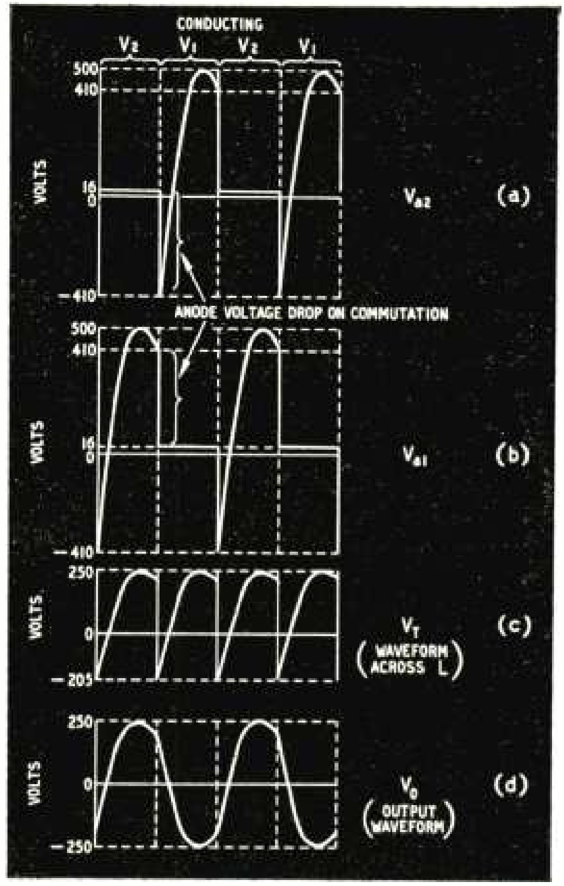


Fig. 6. Waveforms in the circuits of Figs. 5 and 7.

readers who have seen inverter circuits published using self-excitation. At first sight self-excitation appears quite attractive, but there are many pitfalls. One of the biggest snags is starting the operation in the first place. Some authors, in fact, state that a separate (a.c.) source is required to start the action, after which the inverter will run free. Since such a source is required at all, it appears only logical to use it all the time ; we then have the added advantages of better frequency stability, and definite frequency control.

The form of driving oscillator incorporated here is a multivibrator using a 6SN7. The outputs from the two anodes are square waves in antiphase ; these are applied via self-biasing circuits to the respective thyratron grids. The sharp leading edges of the waveforms trigger the thyratrons at a perfectly fixed time, and ensure a stable, jitter-free output.

(b) *Thyratron anode circuit.*—The thyratron selected for use in this inverter is the Marconi or Osram GT1C. It is a small and easily obtainable valve, a pair of them giving a useful power output of some 100 watts (after subtraction of required heater power). The power is limited by the maximum mean cathode current, 0.3A, the maximum permissible anode voltage, 500, and the maximum waveform distortion we are prepared to tolerate.

Using the component values given, the full 100 watts can be obtained with no difficulty, and without undue distortion of the waveform (see Fig. 8).

* This does not mean that $LC = \frac{1}{\omega^2}$. This is only true for a simple high-Q tuned circuit. Here we have a 2 : 1 transformer between L and C, so that the effective capacity is 4C giving (approximately) that $4LC = \frac{1}{\omega^2}$.

The circuit diagram specifies a 240-V winding for the output, but of course any secondary winding can be used, e.g., a 6.3-V supply for valve heaters.

As already pointed out, the regulation is poor, and we therefore include a series dropping resistance in the h.t. line to adjust the a.c. output voltage for each different load.

A very good scheme, where the inverter is required for intermittent use, or for use on several pieces of gear, is to set R so that the inverter just runs its own heaters. A resistance R′ located in the gear itself plugs into the inverter in parallel with R. With the external apparatus switched on, R′ increases the current to the thyratrons, and the inverter is able to cope with the increased load. A graph giving approximate values of R′ for outputs up to 100 watts is drawn (Fig. 9). This graph also gives the power dissipated in R′, together with other data on the performance of the unit.

As a safety precaution for the thyratrons, the makers recommend the use of a 1-amp circuit breaker in the H.T. supply. If the inverter action fails, the thyratron current (usually limited by the transformer primary inductance and L) can rise to several amps, and this will damage the valves. The use of a fuse is not recommended as its action is too slow.

A functional diagram of a simple breaker is given in Fig. 10. The coil carries the normal supply current for the thyratrons (0.6A maximum), and this is insufficient to pull the lever arm over. If, however, the current rises to about 1 amp the lever is attracted to the pole piece, causing the contacts to be released. The supply to the thyratrons is then broken, and can only be restored manually. The device must never be reset with S_2 of Fig. 7 in the " on " position. The current at which the cut-out operates can be adjusted by variation of the spring tension. A reasonably well constructed home-made unit is quite adequate, but suitable cut-outs may also be purchased.

(c) *The switching circuit.*—Before the inverter can be started the heater current must be supplied for the valves. This is done by a series dropper from the mains. The GT1C heaters take 1.3 A at 4 V, and the 6SN7 takes 0.6 A at 6.3 V. Using the series-parallel combination shown, the total heater drain is 1.9 amp at 8 volts (15.2 watts), and a very useful form of dropper is a 500-watt iron element of fire bar. The heaters should be left to run for about a minute. This allows sufficient time for the cathodes to heat up, and for the multivibrator to start functioning. In the first instance it is as well to check (with a high-resistance meter) that each thyratron grid is 10 or 20 volts negative to earth, indicating the presence of a switching waveform. After the warm-up time S_2 may

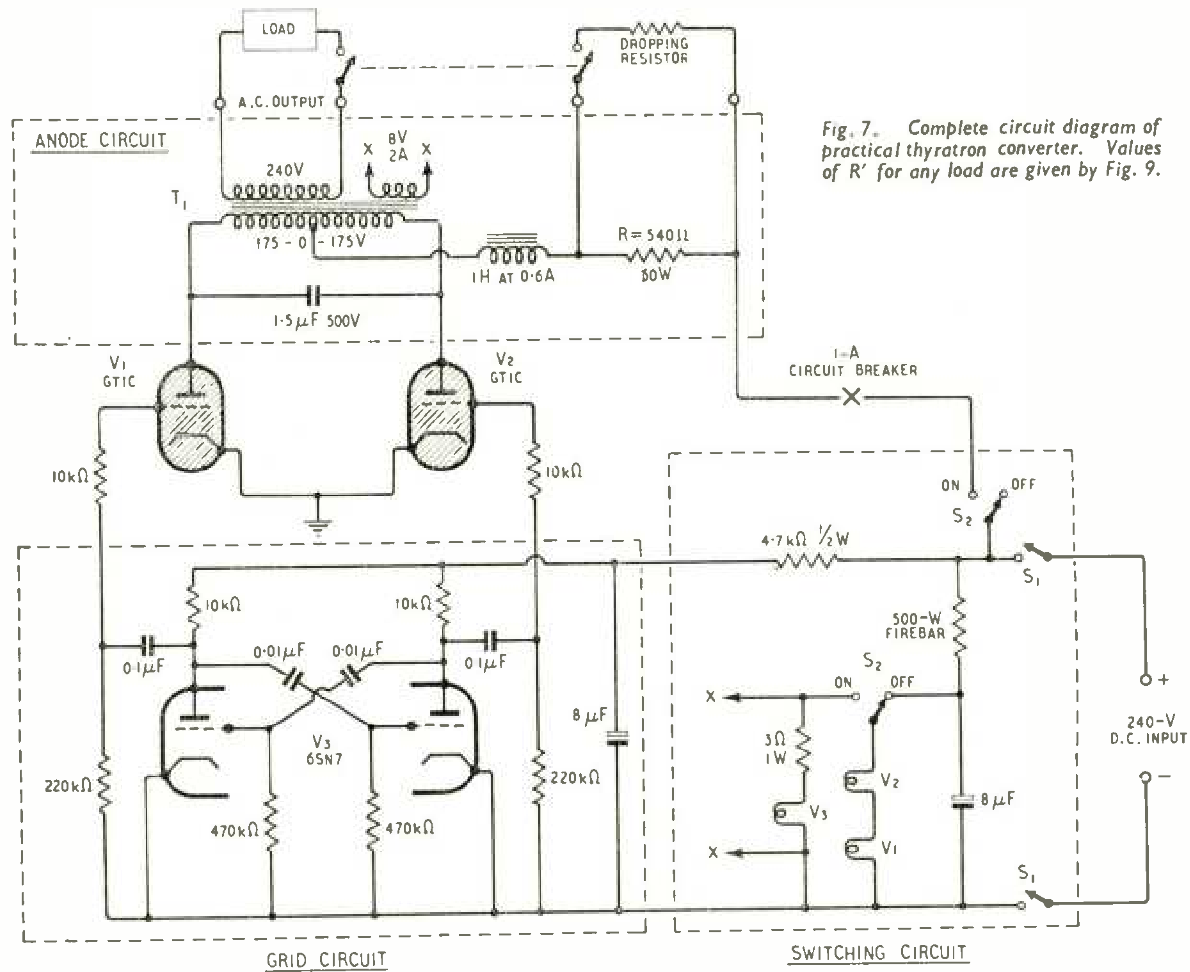


Fig. 7. Complete circuit diagram of practical thyratron converter. Values of R′ for any load are given by Fig. 9.

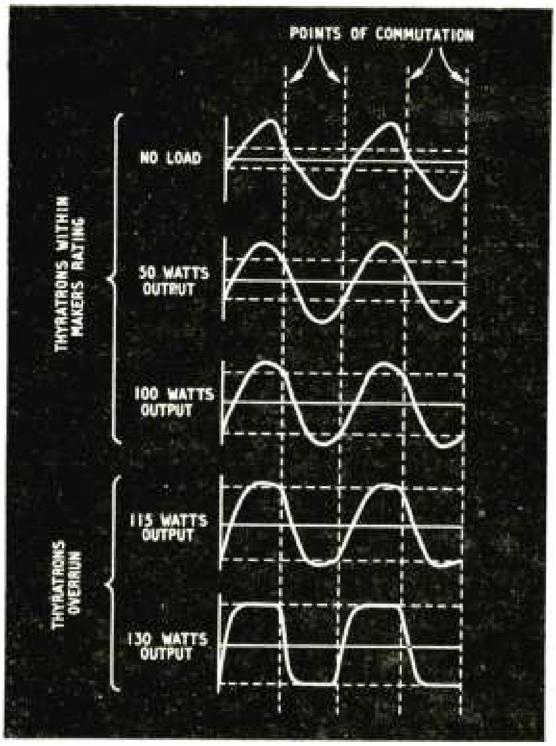


Fig. 8 Output waveform distortion with increase in load. Intersection of broken lines indicate points of commutation.

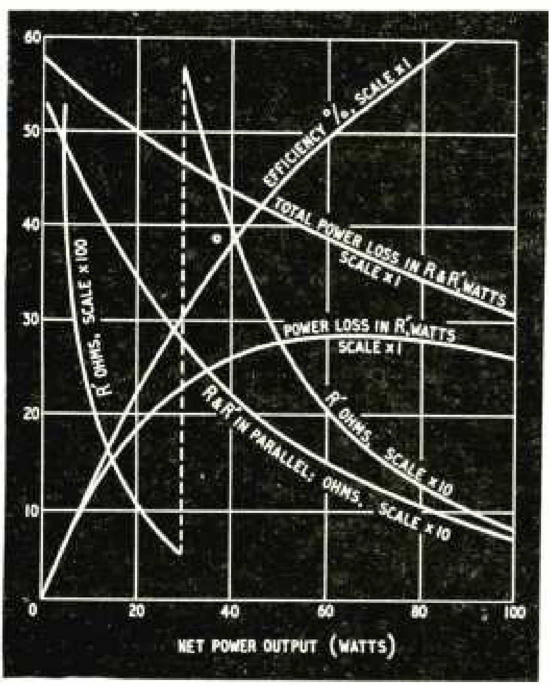


Fig. 9 Approximate values of series resistor and other data on the circuit of Fig. 7.

Fig. 10. (right) Functional diagram of simple circuit breaker.

be thrown to the "on" position, the inverter should then work, and maintain the heater current. Some adjustment of R will probably be necessary to correct the heater voltage.

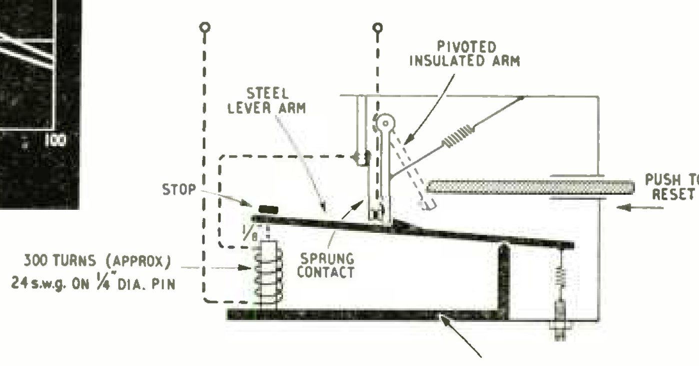
Additional loads may be added to the inverter by use of resistance R′ as already described. Care should be taken that the thyratron heater voltages are never allowed to fall below 4 volts on each valve.

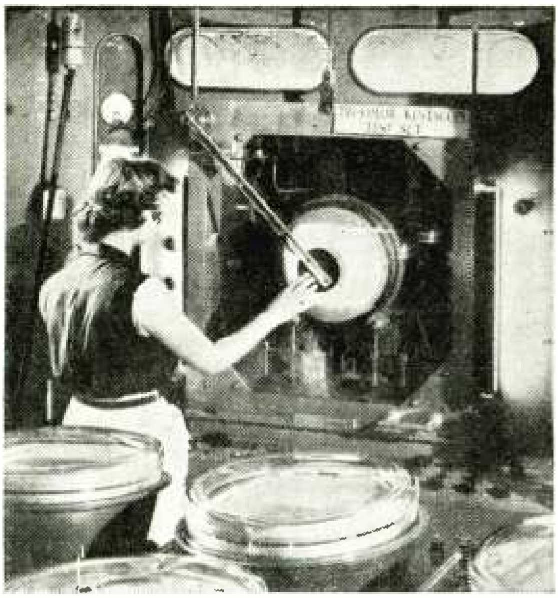
Conclusion.—As a summing up, it may be useful to enumerate in the accompanying table the properties of the thyratron inverter, particularly as a comparison with a rotary transformer.

The author has found the circuit described to be reliable and in every way suited for experimental work. A particularly useful feature for many applications has been the availability of 6.3 volts for use on "lash-up" chassis. In these cases the mains direct has been used for h.t. supplies.

TABLE

	Inverter	Rotary Transformer
1	Entirely electronic, no moving parts, consequently silent in operation.	Mechanical device, continuous wear on moving parts, noisy.
2	Several output voltages of any desired value may be obtained.	Generally wound for only one output voltage.
3	Frequency easily controlled, can be locked electronically to, say, television frame time base.	Frequency predetermined, liable to vary with loading.
4	Regulation very poor. Some form of adjustment is necessary, involving considerable power loss.	Regulation fairly good. Adjustment, if required, can be applied to generator field winding, and it is necessary to control only a small proportion of the total current.
5	Full-load efficiency about 65 per cent. If overloaded, thyratron heaters are liable to be underrun, with consequent damage or failure.	Full-load efficiency probably about 50–60 per cent. No serious damage results from overloading.





Testing the completed tubes for phosphor-dot brightness with a photo-electric light meter on a swinging arm.

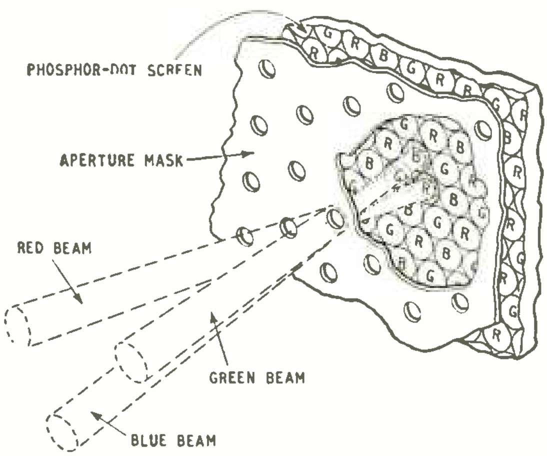


Fig. 1. Showing how the three electron beams are arranged to fall only on their own particular phosphor dots.

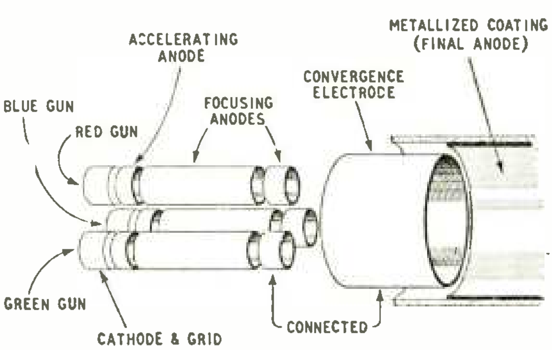


Fig. 2. Sketch (not to scale) of the three electron guns and beam-converging arrangement in the tube neck.

COLOUR

Three Primary Colours from Screen of Phosphor Dots

AS part of the general surge of activity on colour television in the United States, quite a number of experimental designs for tri-colour cathode-ray tubes have been brought out in the past year or so. The first of these, though not necessarily the best, has now emerged from its developmental chrysalis as a bright and shining production model and become available on the general market. It is a 15-in tube, type 15GP22, made by R.C.A., giving a colour picture approximately $11\frac{1}{2}$in $\times$ $8\frac{5}{8}$in.

The 15GP22 is, in effect, three tubes in one. It has three independent electron guns and three sets of phosphors on the screen which emit respectively red, green and blue light when energized. From each gun the electron beam only energizes one particular phosphor, so that the guns themselves can be labelled "red," "green" and "blue," and in the receiver the signals representing the red, green and blue components of the colour picture can be applied to them appropriately. Much the same effect can be obtained by using three separate cathode-ray tubes with red, green and blue screens respectively and combining their images in an external optical system—but here, of course, it is all done in one envelope.

Masking Principle

The method by which each electron beam is made to fall only on its own particular phosphor is most ingenious. Put into practical form and adapted to mass-production techniques, it amounts to a considerable feat of engineering skill. Fig. 1 illustrates the general principle. The three phosphors are applied to the screen as three "interlaced" sets of phosphor dots, which are arranged in triangular groups of three (red, green and blue) as shown. Altogether there are about 195,000 of these dot trios on the screen, or 585,000 individual dots. Behind the screen, at a distance of about $\frac{3}{8}$in, is a thin metal mask perforated with tiny holes—one for each phosphor-dot trio on the screen. The three electron beams from the guns are made to converge on this mask, so that when they pass through a hole each beam falls on a particular phosphor dot in the associated trio. Wherever the beams are swept across the mask by the scanning system the same thing happens at every hole.

As the beams encounter each dot trio in turn they are modulated individually by the incoming signals, and the dots are energized accordingly. Since, however, the individual dots in a trio are too small and closely-spaced to be seen separately by the eye, they are blended together to produce a single continuous colour. The actual hue of this colour mixture depends, of course, on the proportions of the red, green and blue primary-colour components specified by the modulating signals. In effect the whole screen is presenting three independent images in the three

TELEVISION TUBE

primary colours, slightly displaced from each other. The displacement is so very slight, however, that the three images are virtually coincident to the eye of the viewer and the colours are blended together. It will be noted that the definition of the tube is limited by the number of dot trios on the screen, or holes in the mask, and each dot trio can be considered as a picture element.

In an early experimental model of the tube the three beams were made to converge simply by inclining the electron guns towards each other. In the 15GP22, however, the guns are mounted with parallel axes and the converging process is done by an electrostatic lens. Fig. 2 shows the general arrangement. Around each gun cathode is the normal cylindrical control grid (operating at about −45 V to −100 V for beam cut-off) and this is followed by an accelerating electrode working at about 200 V. Next come a long cylinder (working at about 3 kV) and a short one (at about 9 kV) which between them form an electrostatic lens for focusing the beam. After this all three beams pass together through a common, large-diameter cylinder which is connected to the previous three small ones (at 9 kV). This large cylinder and the metallized coating on the inside of the tube neck (operating at 20 kV) together form a second electrostatic lens which causes the three beams to converge. The mechanism here is much the same as the convergence of individual electrons in an ordinary focusing lens, and, indeed, the three beams do receive a certain amount of extra focusing at this point. The degree of convergence, or focal length, of the lens is controlled by varying the potential on the large cylinder.

After leaving the converging lens the beams pass through the magnetic fields of the scanning coils (which are mounted at the usual position on the tube neck) and on to the mask and screen assembly. From here the return path of the beam current is via the internal metallized coating, which constitutes the final anode of the tube. The 20-kV e.h.t. supply is connected to this coating by a circular metal flange round

the outside of the envelope, which is actually a welded joint between the face-plate section and the main body of the tube.

Mechanical Design

The tube is 26in long, has a neck diameter of 2in and weighs 25lb. Its deflection angle is approximately 40 degrees. Other constructional details can be seen from Fig. 3. The phosphor-dot screen is deposited on a tinted glass plate and is metallized on the back in the normal way. The mask is made from a copper-nickel alloy, approximately 0.003in thick, and is clamped in a rigid circular frame which also serves to support the phosphor-dot screen.

One fundamental difficulty in this particular design is that, owing to the screen being flat, the beam-path length from the converging lens to the mask varies

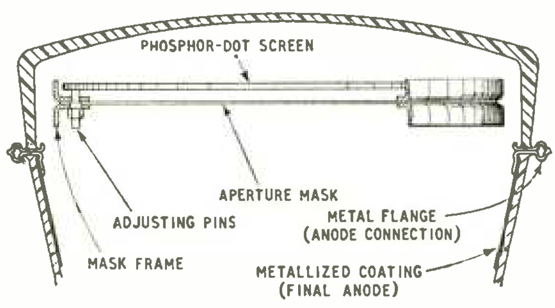


Fig. 3. Mechanical details of the mask and screen assembly.

(Right) A process in manufacturing the phosphor-dot screen. For each set of dots the fluorescent material in paste form is squeezed through a gelatin stencil on to the glass backing plate.

with the angle of scan. Consequently, if the three beams are made to converge (and focus) correctly at the centre of the mask they will not do so at the outer edges. This means that, to obtain correct convergence at all points, the focal length of the converging lens must be made to vary in accordance with the angle of scan. In practice this can be done by deriving a voltage from the line and frame scanning circuits and using it to vary the potential applied to the large-cylinder convergence electrode.

Apart from this, there are one or two other auxiliary devices needed to make the tube work properly. First of all, it has to be protected from extraneous magnetic fields (including that of the earth) by a magnetic shield round the cone. A field-neutralizing coil, wound round the rim of the face-plate and fed with d.c., may be needed as well for this purpose. Next, the three beams have to be properly aligned with respect to the mask and screen assembly by magnetic deflection from a coil round the neck of the tube. Correct alignment is obtained by rotating this coil and adjusting the current through it. Finally, to align the three beams with respect to each other, three small deflecting magnets have to be mounted round the neck at 120-degree intervals and adjusted individually. All this amounts to a considerable clutter of bits and pieces round the tube, but no doubt future designs will dispense with a lot of it.

BOOK REVIEW

Principles of Transistor Circuits. Edited by R. F. Shea. Pp. 535 + xxx. Chapman and Hall, 37, Essex Street, London, W.C.2. Price 88s.

Those wishing to acquaint themselves with the subject of transistor circuits are overwhelmed by the volume of papers at their disposal and, until this recent work by Shea and his colleagues, have had no textbook to turn to for guidance in their reading. In the circumstances almost any book would be welcome; that this particular one contains a considerable amount of useful material and is well written by engineers experienced in transistor circuits makes it highly acceptable.

The book itself is likely to be of most value to engineers actively interested in transistor circuits. It is too detailed for casual reading and the extensive algebraic analysis makes it too unwieldy if one is merely interested in obtaining a general idea of the principles. Engineers already at grips with transistor circuits will find the names of many of the co-authors familiar, since part of the book is based on their published work. Each chapter has a general introduction, which is both useful and interesting, and a number of examples so that engineers and students may practise the principles discussed in the chapter; the only difficulty with this is that no answers are given, thus leaving the keen student to devise some method for checking that his answer is correct.

Over half the book is devoted to transistor amplifiers; because of its highly linear amplification and relative freedom from noise limitations, the junction transistor is the chief device discussed. The analysis is mainly mathematical and is as generalized as possible in order that the book shall not become out of date too rapidly as new types of transistors appear. Thus, in the chapters on high-frequency amplifiers, when frequency is considered it is always expressed in terms of $\omega_{\alpha 0}$ (the frequency at which α, the current gain, is 3 db down from its value at low frequency). This approach is to be recommended even though it may involve some mental efforts to translate the result to a practical circuit.

The chapters on low-frequency amplifiers are very detailed and many useful parameters such as input and output resistances and operating gain are tabulated for easy reference. Three chapters on high-frequency circuits (high is, of course, a relative term and often disappointing to engineers experienced in thermionic valve circuits) include one on narrow-band tuned amplifiers, a very neglected topic in transistor circuits.

A chapter on bias stabilization and one on d.c. amplifiers indicate methods of overcoming a very serious difficulty met with germanium junction transistors; namely, the variation of I_{co} (the collector current when the emitter current is zero) with temperature.

The chapter on power amplifiers barely mentions the possibilities of circuits using both *n-p-n* and *p-n-p* transistors at the same time (complementary symmetry) or of those using specially made junction transistors where the role of emitter and collector can be interchanged by merely reversing the sign of the bias applied. Evidently the book was completed before these interesting and important possibilities were fully appreciated.

The chapter on oscillators is disappointingly scanty. The chapter on transistors in computer circuits is also very brief though this weakness is somewhat mitigated by a chapter on transient analysis where the difficulties of switching a transistor amplifier from low to high conduction and *vice versa* are discussed in some detail.

Duality between transistors and thermionic valves, matrix methods of network analysis, noise, the measurement of the parameters of the small signal a.c. equivalent network, and semi-conductor devices other than transistors are all discussed in separate chapters. A somewhat compressed introductory chapter indicates the physical principles of semi-conductor devices.

The book is well produced and contains an extensive bibliography. All the symbols used, as well as the first page they appear in the text, are listed at the beginning. Its chief limitation is its very high price. D. D. J.

BOOKS RECEIVED

Applied Electronics Annual 1953/54. Edited by R. E. Blaise, A.M.Brit.I.R.E. International directory of manufacturers of radio and electronic equipment, prefaced by articles on recent developments in many branches of the art. Pp. 257 with numerous illustrations. Price £1. British-Continental Trade Press, 222, Strand, London, W.C.2.

Einschwingvorgänge Gegenkopplung, Stabilität, by J. Peters. Theoretical foundations and application of feedback in amplifiers, mechanical and electro-mechanical systems, and their stabilization. Pp. 181 + xv; Figs. 130. Price DM27. Springer-Verlag, Reichpietschufer 20, Berlin, W.35.

Radio Control of Model Aircraft, by G. Sommerhof. Outline of basic principles of radio control, with constructional details of a transmitter and receiver, and associated electro-mechanical devices. Pp. 164; Figs. 87. Price 9s 6d. Percival Marshall and Company, 23, Great Queen Street, London, W.C.2.

How to Use Meters, by John F. Rider. Description of principal types of pointer instruments, valve voltmeters and their use in maintenance and experimental work. Pp. 156; Figs. 153. Price $2.40. John F. Rider, Publisher, 480, Canal Street, New York 13.

TV Trouble Shooting and Repair Guidebook, Vol. 2, by Robert G. Middleton. Deals particularly with r.f. and i.f. amplifiers, detectors and audio stages. Pp. 156; Figs. 187. Price $3.30. John F. Rider, Publisher, 480, Canal Street, New York 13.

Vacuum Lamp Interference

R.F. Oscillations from Electric Light Bulbs

By "CATHODE RAY"

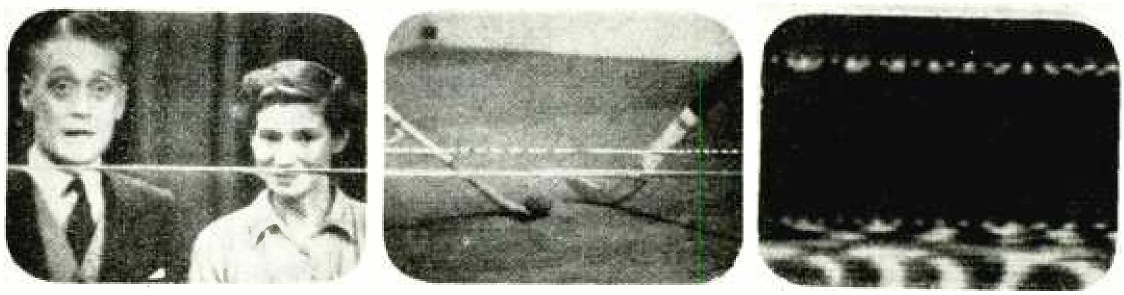


Fig. 1. Example of lamp interference on television pictures.

IF you think you have seen Fig. 1 before somewhere, you are quite right. It appeared as recently as the March issue, p. 102, to illustrate a short note summarizing the findings of 1953 *Wireless World* correspondence on lamps as sources of interference with television. The main point put on record was that gas-filled lamps may interfere when they are so near the end of their life that a microscopic break occurs in the filament, across which an arc is produced, but vacuum lamps can radiate interference throughout their life. No explanation was offered of how vacuum lamps managed to perform this remarkable but objectionable feat, so I have looked into the matter to see if it could be explained.

Fig. 2. Typical tungsten filament in vacuum lamp.

Not having actually experienced any of this particular brand of interference, I set about getting some. To do this it was necessary, as Mrs. Beeton might have said, to first catch one's lamp. Some of the younger readers not only may never have seen a specimen of the required type but may even be rather hazy about what a vacuum lamp is. It has long been displaced by the gas-filled lamp for domestic purposes, but apparently is used to this day for a few special applications, mostly connected with transport. As a matter of fact I had to poke around for some time in a dusty old junk box near the ceiling before I could find one. It was an authentic specimen of the kind that must be familiar to all in what I will tactfully refer to as the upper age groups; a long zig-zag filament suspended between two sets of glass-mounted spokes as in Fig. 2. In case it is of interest to anybody, here is the information it carried on the bulb:

3.1.18
Pope "Elasta"
British Made
200-32

The 200 presumably refers to the voltage, and the 32 takes one back to a still earlier era when the carbon-filament lamp reigned supreme, and as the less that was said about its consumption the better it was usually rated not in watts but in candle-power—8, 16, or 32.

Having found my vacuum lamp. I plugged it in and brought it near the television receiver; but with no effect on either picture or sound. The next thing was to dig out the v.h.f. super-regenerative receiver described in the January, 1947, issue, and put near it the lamp connected to a variable source of 50-c/s a.c. To give it a better chance I put a pair of r.f. chokes in the leads close to the holder, and a by-pass capacitor, as in Fig. 3. This worked right away, producing a broad band of interference. By varying the voltage, the centre of the band could be shifted, from about 75 Mc/s at 200V to 56 Mc/s at 145V, below which oscillation ceased altogether. The lack of TV interference in the preliminary test was thus explained, for the local station is Channel 1, 45 Mc/s.

Varying C in Fig. 3 from 0 to 500 pF had only a minor effect; the less the capacitance the higher the frequency, but the whole variation was only a mega-

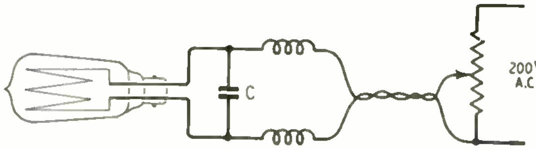


Fig. 3. First experimental lamp oscillator. This proved to be needlessly elaborate.

cycle or so. With 500pF, oscillation seemed a little less ready than with, say, 25 or 50. Removing the chokes made no noticeable difference. In other words, the lamp interfered at least as merrily when connected in the ordinary way at the end of a piece of flex as with any combination of tuning components. The only thing having a substantial effect on the frequency was the voltage. Remember, there is a good vacuum in this kind of lamp, so there is no question of gas discharge, as with the interference caused by neon lighting and a small proportion of fluorescent lamps. It is genuine v.h.f. oscillation, modulated in amplitude and frequency at 50 c/s.

Just to complicate the problem, oscillation ceased every time I drew my hand rapidly away from the bulb, and was stimulated by moving it towards the bulb. Let me emphasize that *holding* the hand at any point within this range of movement—about ½in to 6in from the bulb—did not produce the effects mentioned; they depended entirely on movement. An exception was that actually touching the bulb about its middle invariably stimulated oscillation, and in fact was the most certain way of reviving it when it had petered out, as it was apt to do on slight provocation, such as shifting the position of the lamp. Various arrangements of wires and metal plates, earthed, unearthed, or connected to either lamp terminal, produced sundry effects, but none so marked as with the hand.

Since the main factor controlling frequency was voltage, which with an a.c. supply is varying all the time, it was obviously going to simplify the situation somewhat if the lamp were fed with d.c. This was rigged up with the aid of a mercury rectifier and a smoother that left enough ripple to be heard on the receiver. The general results were very similar to those obtained with a.c., except that as expected there was less frequency modulation, so interference was confined to a narrower band. The tendency for oscillations to fade out was more marked, and it was difficult to keep them going at all unless the lamp holder was connected straight to the supply, without any chokes, etc. The voltage required to tune to a given frequency was nearly 30% higher than the r.m.s. voltage with a.c. (but somewhat lower than the peak voltage), and with 135V ceased altogether, the last measured frequency being 42 Mc/s.

One-Electrode "Valve"

Some months ago* I extolled the marvels of the magnetron, which, though a mere diode, oscillates to such intense effect in the centimetre wavebands. We might feel sure that two was the absolute minimum number of electrodes for true electronic oscillation. Yet here we have a "valve" consisting of filament only, so presumably classifiable as a monode, working as a complete v.h.f. transmitter, without the aid of anything except an ordinary domestic a.c. or d.c. supply. How does it do it?

The best clue was given by A. Q. Morton in a letter in the July, 1953, issue—his reference to an article by P. S. Rand in *CQ*, July, 1952. This article is worth reading not only for the information presented but for the ingeniously humorous manner of presentation. The vital essence, however. is a reference to Barkhausen and Kurz. Old hands will no doubt have their mental bells set ringing by the mere mention of those magical names, but the younger may experience no

* "Valves for Microwaves," Sept., 1953.

Fig. 4. Barkhausen-Kurz oscillator circuit.

reaction. Barkhausen and Kurz created a considerable stir in highbrow circles from 1920 onward by their disclosure of the type of oscillation named after them. It is obtained with a triode having a positive voltage applied to the grid, and zero or slightly negative anode. The oscillatory circuit consists of parallel Lecher wires, as in Fig. 4. The object of tuning these leads is not to vary the frequency—for their effect on it is slight—but to facilitate oscillation at the frequency set by the grid voltage.

Electrons and Fields

A tremendous lot has been written and talked about Barkhausen-Kurz oscillations, and one can soon get tangled up in a confusion of complication; but there seems to be general agreement about the main essentials of the story. It has much in common with the one I told about magnetrons in "Valves for Microwaves." The underlying principle is that if an electron (or any other electrically charged body) moves *with* an electric field, it *receives* energy, and this energy is manifested as acceleration; if it moves *against* the field it *gives up* energy and consequently loses speed. In the magnetron, electrons are attracted by the h.t. from the cylindrical cathode to the surrounding anode, and this anode is divided into segments by resonant cavities, which have oscillatory voltages superimposed on the common h.t. Those electrons that happen to come under the influence of the oscillatory field in such a phase as to be moving with the field draw energy from it, but use it to their own destruction, or at least their speedy removal from the arena. Those that arrive against the field give up some of their energy (which has been given them by the h.t.) to help keep the oscillations going, and thanks to the subtle interplay of electric and magnetic fields they are able to continue doing this for some time as they dance around. So their contributions of energy far outweigh that taken away by the drone electrons in their much shorter lives.

Something of the same kind is responsible for B-K oscillations. The electrons leaving the cathode are attracted by the positive grid and accelerate violently towards it. But because it is a grid, there is plenty of space between its wires for electrons to go through, and most of them do this. They then find themselves confronted with a negative or at most zero-potential anode, and the positive attraction is now backward. So they are first retarded to a stop and then accelerated back to the grid. Again some go through, and the whole process is repeated until sooner or later they get caught. If you like the rolling-ball analogies we used recently, you can picture the zero-potential cathode and anode as ridges with the positive grid as a trough in between. The balls released at the cathode ridge gain speed as they roll down to the grid, and a few of them are collected there, but most go past and their momentum carries them nearly to the top of the anode ridge; then they roll back, and continue with a sort of to-and-fro pendulum movement. For a given weight of ball, the time for each to-and-fro cycle depends on the distance between the ridges and on the depth of the trough. Similarly the time for a cycle of electronic oscillation depends on the distances between the electrodes and on the grid voltage.

Assuming now, as we did with the magnetron, that the grid potential is oscillating above and below the steady h.t. voltage, at the same frequency as that of the electrons in and out of the grid wires, the electrons that leave the cathode just as the grid is becoming more positive are accelerated more than they would have been without the oscillatory potential. This extra acceleration is at the expense of that potential. And because of the synchronization of frequency, by the time the electron has gone beyond the grid the grid potential has reversed and so the electron is retarded less than it would have been. The net result of greater speed and less braking is that the electron fails to pull up before it reaches the anode, into which it crashes and is thereby removed from the event on the first lap. This, of course, is just what it deserves for stealing energy from the grid oscillation.

Electrons that start just as the grid is beginning its negative half-cycle are accelerated less than with the h.t. alone; and when they get beyond the grid they are retarded more. So all the time they are giving up their energy to the grid and their swing becomes less and less every half-cycle. There is consequently no risk of being collected by the anode, and they have a sporting chance of clearing the grid several times in succession (Fig 5). So, as in the magnetron, if conditions are favourable the energy-giving electrons are more effective than the one-lap energy-taking electrons, and the net result is a build-up of oscillation.

Oscillator Components

What has all this to do with lamps? Well, the only major frequency-controlling factor in the B-K oscillator is the grid voltage. The only major frequency-controlling factor in the lamp oscillator is the applied voltage. This voltage is applied between one end of the filament and the other. Every part of the glowing filament emits electrons and is in a vacuum, so is potentially a valve cathode; and every part is likewise a grid because it is that shape. So when a suitable voltage is applied between one end and the other (either continuously or alternately) the

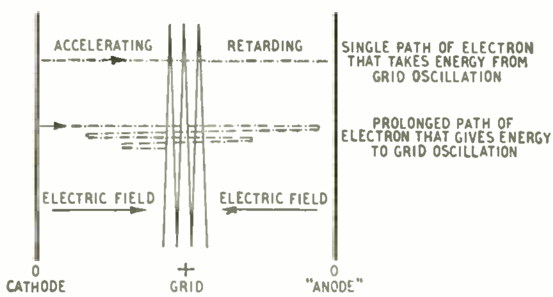


Fig. 5. In a B-K oscillator, electrons that come at the right moments to build up grid oscillation tend to have longer runs than those that damp it down, and so they prevail.

negative end is a cathode and the positive end is a positive grid. The rest of the filament forms a zig-zag loop between the two, having distributed inductance and capacitance. So all the parts of the B-K oscillator seem to be present and correct except the anode. Another difference is that the "tuned circuit" is connected to the cathode instead. As far as potential is concerned there is nothing wrong with that. And the only purpose of the "anode" (it is really no such thing in this case) is to be at somewhere near cathode potential so as to ensure that the space between it and the grid has an electric field that is positive gridwards. P. S. Rand gets over the missing electrode problem by saying "The plate being negative does nothing and might as well be left out." That seems to me just a little too glib. My theory is that the bulb is the "anode."

Unauthorized Anode

After all, it wouldn't be the first time. Quite a long while ago* an article appeared by K. A. Macfadyen entitled "A Form of Distortion Known as the 'Buzz Effect'." This showed very convincingly that a certain hitherto mysterious buzz superimposed on sound reproduced by some pentode output valves was caused by the getter—the metallic layer deposited on the inside of the bulb during manufacture—acting as the anode in a dynatron. Only last month, in 'Relaxation Oscillators," we had occasion to refer to an anode-current/anode-voltage diagram with the dynatron kink in it, and a load line cutting it at three possible working points, one of which we found to be impossible—at least for any period of time exceeding zero. Mr. Macfadyen uses exactly the same diagram to show that the unauthorized getter anode goes through sudden violent jumps up and down in potential as the real anode (which unbeknown is acting as the second grid in a dynatron) is trying to execute nice smooth ellipses to give nice smooth bass notes to the loud speaker but is frustrated therein by the said jumps working back via capacitance coupling to the control grid and injecting nasty spiky noises into the programme. Don't waste too much time puzzling this out—the details are not important just now. The main thing is the bulb acting as an electrode. (Incidentally, I usually back the British term "anode" against the American "plate," but with so many electrodes in disguise or playing the wrong roles it is becoming a little difficult!)

You may say that that is all very well, but lamps don't have metallic coatings on the insides of their bulbs—they would stop the light getting out. Certainly lamps wouldn't be very saleable if they were gettered like valves; but for our present purpose we are not looking for a dynatron anode but only for somewhere that can be at about zero potential, and I seem to remember that the whole subject of electronics is generally reckoned to have begun in 1883, when Edison, who had been trying to find a cure for the bulbs of his lamps blackening on the inside with use, discovered that an electric current could pass across the vacuum between filament and bulb. Presumably some trace of metallic coating accumulates, even in more modern lamps, and electrons shot against the bulb by the field we have already discussed tend to charge it negative and so establish a retarding field as required for B-K oscillations.

* *Wireless Engineer*, June. 1938, p. 310.

As it happened, looking up Macfadyen's article I found (what I had completely forgotten) that he goes on from buzz distortion to explain radio interference from vacuum lamps! But apparently the interference he explained was different from the kind we are trying to explain: first, because his interference occurred throughout the band 3 to 30 Mc/s; and secondly, because the dynatron effect was stopped by an earthed coating outside the bulb, whereas that invariably stimulated our kind of interference to greater achievements. No; the interest of this article for our present enquiry lies in its confirmation that the inner surface of a vacuum lamp bulb can act as an electrode. Incidentally, according to a formula quoted by F. E. Terman, giving the frequency of B-K oscillation in terms of voltage and electrode spacing, the spacing in my lamp works out at about 2 cm, which is just about what it is.

So now we have accounted for the whole B-K outfit. What is more, unless I am mistaken we have accounted for the Mystery of the Moving Hand. If an earthed body (mine, in this case) is suddenly moved to a charged body, the capacitance of the charged body to earth is increased, and in accordance with the relationship $Q=VC$ the potential of the charged body is lowered. And vice versa when I move my body away. My theory is therefore as follows. The inner surface of the bulb, on the opposite side of the positive end of the filament ("grid") from the negative end ("cathode") is being bombarded with the electrons that miss the "grid." It therefore becomes negatively charged with respect to the "grid," until the charge is sufficient to keep away the retarded energy-contributing electrons and B-K oscillations can begin. The energy-receiving electrons that crash into it probably cause secondary emission that results in the potential becoming stabilized at a level that is still slightly more positive than "cathode." Bringing a hand quickly towards the bulb causes the potential to drop nearer zero ("cathode")—a condition that favours the oscillation. But when the hand somes to rest the newly increased value of capacitance charges up to the original potential and oscillation reverts to normal. Taking the hand rapidly away raises the potential enough to stop oscillation altogether, but when that incident is over the bulb comes back once more to normal. Holding the bulb firmly, on the other hand, keeps the inner surface at a lower potential by conduction through the warm glass as long as it is held.

If you have a better story, don't hesitate to send it in for general information.

CODES OF PRACTICE

ARRANGEMENTS have been concluded whereby with effect from April 1st, 1954, the preparation and publication of all Codes of Practice will in future be the responsibility of a council within the framework of the British Standards Institution. Hitherto such codes were prepared by the Ministry of Works or the professional institutions concerned, but they were often issued by the B.S.I.

Essentially, codes of practice are concerned with setting out tried and proved methods of operation, installation and maintenance of plant, machinery and equipment, etc., as opposed to manufacturing requirements and processes which take place before plant and equipment leaves the factory. Codes are thus closely related to, although quite distinct from, the standard specifications which form a large part of the work of the British Standards Institution.

The structure of the B.S.I.'s Council for Codes of Practice will be a broad one; its members will be drawn from the professional institutions and such Government departments that may be concerned. It will have a total of 51 members. Much of the work will be carried through by small specialist committees and panels with members drawn from institutions primarily concerned with the subjects to be considered.

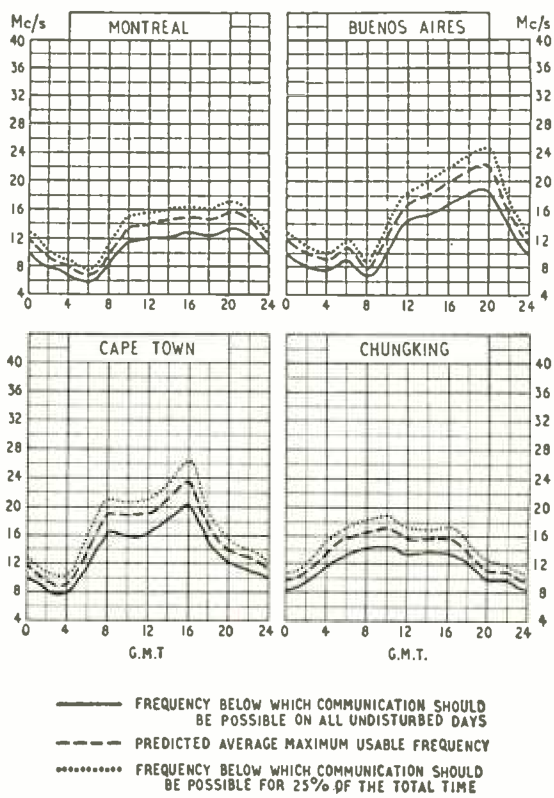
A recent example which has just appeared is a code of practice on "The Use of Electronic Valves," CP 1005: Parts 1 & 2: 1954. This has been prepared by a joint committee of the I.E.E. and the B.S.I. and covers receiving valves, cathode-ray tubes, rectifiers and thyratrons. It is issued as a small booklet of 38 pages by the British Standards Institution, 2, Park Street, London, W.1, and costs 6s.

Short-wave Conditions

Predictions for May

THE full-line curves given here indicate the highest frequencies likely to be usable at any time of the day or night for reliable communications over four long-distance paths from this country during May.

Broken-line curves give the highest frequencies that will sustain a partial service throughout the same period.



Transistor Mortality

Symptoms and Causes of Early Failure

ABOUT two years ago a paper by J. A. Morton (*B.S.T.J.*, May, 1952, pp. 411-442) included an estimate of the average life of transistors. The figure was a heartening one, 70,000 hours, and most equipment designers must have been impressed by the contrast between this figure and the conservative 1,000 hours of the valve manufacturers. On a 24 hour a day basis, 70,000 hours is just about eight years, though the evidence was not enough to indicate whether the life would be eight years or 70,000 hours of operation. The transistors for which this estimate was given were operating as Class A amplifiers, in the laboratory, and had already run for 20,000 hours. Users were therefore rather alarmed when their own transistors appeared to be liable to much earlier death. Increased temperature and increased humidity, in particular, cause quite a lot of trouble, and a new survey of transistor reliability by Ryder and Sittner (*Proc. I.R.E.*, Feb., 1954, p. 414) discusses the present status of "transistor toxicology." Four main ailments are listed in this paper, and we cannot do better than repeat the description given by Ryder and Sittner:

'1. A very gradual drift in the characteristics with time. Particularly affected are the reverse currents of the collectors, both point and junction. This disease was the factor which limited the life to 70,000 hours in the original life tests; since it ordinarily takes a long time to become appreciable, it is known as the "slow death."

2. A gradual development with time of what appears to be a leakage path between the collector and emitter. Not very noticeable in most point-contact transistors, this disease is more virulent in junction transistors, particularly grown types which normally have very high resistance levels; it shows up as a variable floating potential on the emitter when the current is cut off. Since the ailment concerns emitter current cutoff conditions, it is called "sleeping sickness."

3. In some point-contact transistors the current multiplication factor, alpha, may become markedly reduced, particularly at low voltages. Though normally rare, this occurrence has at times reached an incidence as high as 25 per cent for some types. Since this disease may occur quickly without previous warning, it goes by the name "sudden death."

4. Sometimes loss of alpha has occurred prior to receipt of the transistor by the customer. Such units are declared "dead on arrival."'

"Slow death" appears to be caused by changes in the surface conditions as a result, mainly, of water vapour. Exposure of an unprotected *n-p-n* junction unit to 54 per cent relative humidity, which is not a very damp climate, causes the current to rise from 2 to 1,000 μA. The change is rapid and reversible. Normally, of course, the transistor is enclosed in wax and some sort of protective case, but the wax and plastic cases used merely slowed down the effect, and slowed down the reversal. An increase of ambient temperature by 10 deg C doubles the rate at which water vapour diffuses through the wax, and in another type of junction transistor the current doubled after 80 hours at 45 deg C and 100 per cent humidity. Point-type units remained good after 2,500 hours at 55 deg C and 100 per cent humidity.

These point types, however, were liable to "sudden death." Fig. 1 shows, for the benefit of those who are lucky enough not to have encountered this effect, the change in characteristics which takes place. There has been a very large drop in the value of alpha, and the "dead" transistors would clearly be of no use in switching circuits. Investigation has shown that the effect is due to very small rocking of the contact points, most probably because of slight warp-

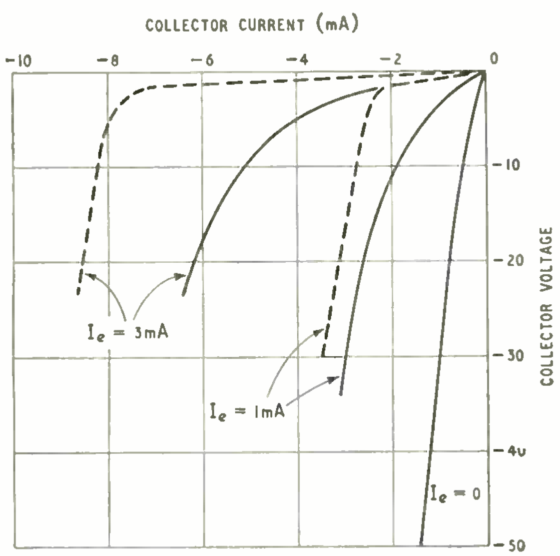
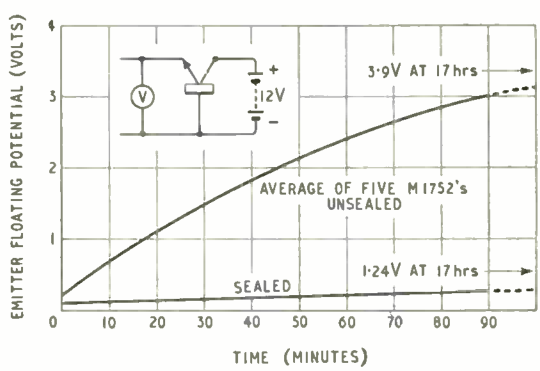


Fig. 1. (Left.) Point transistor characteristic (full lines) before and (dotted lines) after "sudden death."

Fig. 2. (Below.) Effect on emitter floating potential ("sleeping sickness") of sealing grown n-p-n junction transistors.



ing of the plastic supporting insulator resulting from moisture absorption. Design changes which have been introduced appear to have cured this trouble, and it seems likely that if a 24-hour accelerated ageing process is used to eliminate faulty units the particular point type studied might be regarded as immune from humidity troubles.

"Sleeping sickness" affects the grown junction types, and the method of measurement and the results obtained are shown in Fig. 2. The emitter is left open-circuited and the normal collector bias applied: in a "good" transistor the emitter should float at about 0.05 volts, but if there is any leakage across the base, which in the grown junction units is very thin, the emitter will drift up to a much higher potential. Water is probably the main trouble again, but here cleaning, surface treatment and great care to avoid sealing in troublesome ions are required. In the alloyed type of junction transistor the trouble is much less serious, because of the longer leakage path.

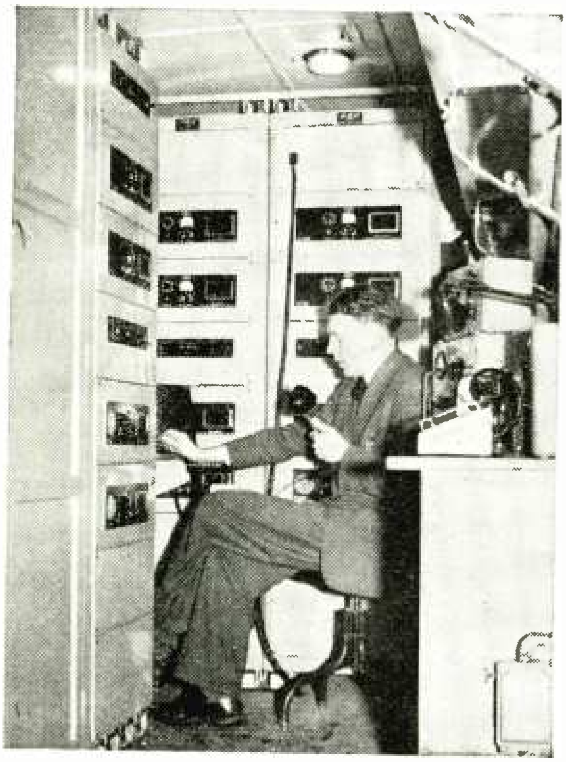
The authors of this paper express their belief that hermetic sealing may not be necessary for all applications, and that plastic cases and new surface treatments may suffice for the more pedestrian circuit functions.

Acknowledgments. Fig 1 is based on Fig. 6, and Fig. 2 on Fig. 16 of "Transistor Reliability Studies," by R. M. Ryder and W. R. Sittner, *Proc. I.R.E.*, Vol. 42, No. 2, Feb., 1954.

V.H.F. DEMONSTRATION VAN

THE illustration shows the interior of a van especially fitted to enable "on the spot" demonstrations to be made of the General Electric Company's v.h.f. communications equipment. It is generally used in conjunction with a mobile satellite consisting of a radio equipped shooting brake.

Radio equipment comprising six transmitter-receivers of various types (f.m. and a.m.) are installed in three 6-ft enclosed racks inside the van; two occupy a position backing on to the driver's compartment, while the third is on the near side adjacent to a tall cupboard. All racks are mounted on shock absorbers.



Interior of the v.h.f. demonstration van equipped by the General Electric Company.

Fixed to the near-side of the van between the equipment racks is a small folding table which serves as the operating position and is fitted with a microphone and loudspeaker control panel.

On the off-side of the van is a well-equipped workbench and above it a cupboard extending the full length of the van. Below the cupboard is stowage space for the sections of a portable 55-ft light-alloy mast.

At the front end of the workbench facing the operator's table is a power distribution panel from which radiate a.c. and d.c. lines operating the radio equipment, supplying light in the van and such other purposes as may be required.

Failing access to a mains electric supply two alternative sources of power are available. One is a 24-V battery-driven d.c.-to-a.c. converter for short-period operation; the other is a portable petrol-electric generator for use when several days are spent at an isolated site. A battery charger is also included.

Higher Technology

IT is not surprising to learn that one of the most successful specialized courses of lectures, if not the most successful, in London and the Home Counties was that on "Crystal Valves and Transistors" recently held at the Borough Polytechnic. There were over 300 applications and the demand was such that the course was repeated.

The success of this course was instanced by the Regional Advisory Council for Higher Technological Education as indicative of what can be achieved when industry makes known its needs for specialized courses of instruction. The Council for London and the Home Counties is anxious that the radio and electronics industry should know that in addition to publicizing courses introduced by colleges and institutes the Council is willing to sponsor advanced short courses for scientists and technologists in industry. There are advisory councils in each of the other nine regions who would doubtless similarly co-operate.

Details of the special courses available in the spring and summer terms this year are given in Part 2 of the Bulletin issued by the London Regional Advisory Council. It is obtainable from Tavistock House, Tavistock Square, London, W.C.1, price 1s 6d.

MAY MEETINGS

Institution of Electrical Engineers

Radio Section.—"The Reflection and Absorption of Radio Waves in the Ionosphere" by W. R. Piggott, B.Sc., and "Some Notes on the Absorption of Radio Waves Reflected from the Ionosphere at Oblique Incidence" by W. J. G. Beynon, Ph.D., D.Sc., at 5.30 on May 5th at Savoy Place, London, W.C.2.

North-Eastern Centre.—Faraday Lecture on "Electro-Heat and Prosperity" by O. W. Humphreys, B.Sc., at 7.0 on May 4th at the City Hall, Newcastle-upon-Tyne.

South-West Scotland Sub-Centre.—Faraday Lecture on "Electro-Heat and Prosperity" by O. W. Humphreys, B.Sc., at 7.0 on May 6th at the Royal Technical College, Glasgow.

British Institution of Radio Engineers

London Section. — "Microwave Measuring Equipment" by P. M. Ratcliffe at 6.30 on May 5th at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.

Merseyside Section.—Annual general meeting followed by programme of technical films at 7.0 on May 6th at the Electricity Service Centre, Whitechapel, Liverpool, 1.

British Sound Recording Association

London.—"Voices and Sounds from History" by Brian George, illustrated by recordings from B.B.C. archives, at the annual convention at 7.0 on May 21st at the Waldorf Hotel, Aldwych, London. W.C.2.

Royal Society of Arts

"Colour Television" by Cdr. C. G. Mayer, O.B.E., (R.C.A.) at 2.30 on May 5th at John Adam Street, Adelphi, London, W.C.2.

Television Society

London.—"Receiver Design for 625-line Systems" by Dr. A. J. Biggs (G.E.C. Research Laboratories) at 7.0 on May 14th at the Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, London, W.C.2.

Institute of Practical Radio Engineers

Midlands Section.—"Sobell Television Receivers" by C. W. Sheffield (Sobell) at 7.30 on May 3rd at the Crown Hotel, Broad Street, Birmingham.

Electro - Physiological Technologists' Association

London.—The annual general meeting, followed by a series of papers and demonstrations, will be held this month. Particulars from the secretary, G. Johnson, Hurstwood Park Hospital, Haywards Heath, Sussex.

Institute of Navigation

"Visual Aids to Bad-Weather Approach" by Dr. E. S. Calvert at 5.0 on May 21st at the Royal Geographical Society, 1, Kensington Gore, London, S.W.7.

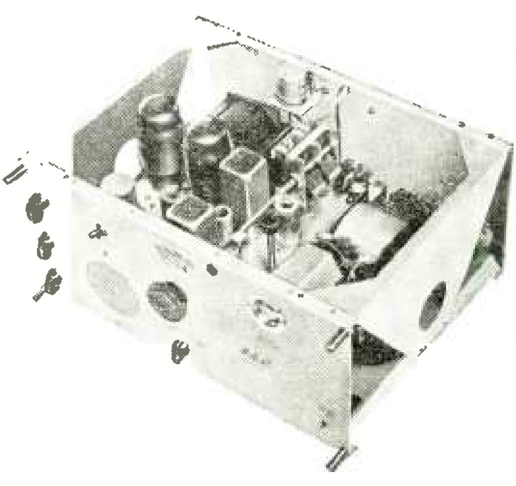
Versatile Industrial Receiver

A RADIO receiver designed especially for use in medium-sized industrial premises, in hotels, hospitals and clubs has been introduced by the General Electric Company, Kingsway, London, W.C.2. It is of unit construction consisting of a sensitive superheterodyne radio receiver, a 15-watt audio amplifier capable of operating up to 30 extension loudspeakers and an a.c. power supply unit.

A centrally placed selector switch gives choice of medium- and long-wave broadcast, gramophone reproduction or microphone input for announcements and paging. In addition to the customary tuning control there are controls for output, tone and an on/off switch for a built-in 3½-in monitor loudspeaker.

The output transformer is designed to work into a 250-ohm line; it is centre-tapped and balanced to earth with an electrostatic screen between primary and secondary. Two sets can therefore be used to supply over a 4-core cable the choice of two programmes without fear of "cross-talk."

The receiver is available in two styles, a chassis model in a grey enamelled steel cabinet (BCS2353) and a rack-mounting model (BCS2354). The former costs £53, the latter £51 10s and the U.K. purchase tax in both cases is £3 15s 9d.



G.E.C. industrial receiver, Model BCS2353, withdrawn from its cabinet.

RANDOM RADIATIONS

By "DIALLIST"

Proof by Nine

HERE is an arithmetical curiosity that I haven't come across in this country, though on the other side of the Channel everyone, from schoolchildren to stockbrokers, makes much use of it. The French call it "La preuve par neuf," or proof by nine. This is how it works. You have multiplied, let us say, 729,534 by 835 and want a quick means of checking the correctness of your result, 609,160,890. Draw a large X. Add the digits of the multiplicand, leaving out any nines: $7+2=9$; drop this 9 and the third digit, which is also 9; then $5+3+4=12$. Go on adding: $1+2=3$. Write 3 in the top angle of the X. Add the digits of the multiplier in the same way: $8+3+5=16$; $1+6=7$. Write 7 in the bottom angle. Multiply together the two numbers now in the X and add the digits as before: $7\times3=21$; $2+1=3$. Write 3 in the right-hand angle. If your answer is correct, its digits, continuously added and with the nines dropped, will come to the same number as that in the right-hand angle (3). We have then: $6+1+6+8=21 : 2+1=3$. The answer is right, unless, of course, you have made several bloomers whose combined effect is to make the digits add up to 3.

Any Suggestion?

It ought to be possible to show algebraically why the proof by nine works. The key seems to be that in the continuous additions you're using not a decimal but a nonal system, for nine is your highest number, being replaced by nought whenever it is reached. I've dim recollections of seeing a process called "casting out the nines" or something of that kind in an ancient arithmetic book. Was that, perhaps, the same thing? I hope, anyhow, that some mathematically minded reader will send us the proof.

Just the Thing

THE IDEA that occurred to me as I was looking through J. L. Osbourne's article on the making of a miniature t.r.f. receiver for the medium waves in last month's *Wireless World* may also have inspired a good many others who read it. There's bags of room in the loudspeaker compartment of my console television receiver and I have been meaning for some time to fit a small medium-wave radio set into it for reception of the local stations. With certain small modifications (no dyed-in-the-wool wireless man can resist making them!), this little set seems to be the very thing one was looking for. My television receiver has, alas, a live chassis as nearly all have to-day. That will mean using a 4-pole change-over switch: one pair of its contacts will take charge of the mains leads; the other pair will connect the existing loudspeaker to the appropriate output transformer. This switch, as well as the knob of the tuning capacitor and that of the gain control, will be out of sight at the back of the cabinet, but easily accessible. The chassis of the radio receiver will naturally be isolated from that of the television set.

TV Screens Too Big?

THOUGH each passing year brings TV receivers with bigger and bigger screens, it does not also bring larger and larger rooms in which to use them. I'm not at all sure, in fact, that we haven't reached (or even possibly passed) the maximum size for 405-line domestic viewing. I happen to live in a house built over thirty years ago in which the living rooms are considerably bigger than those of more modern homes. In two of them, for instance, one's eyes could be up to 20 feet from the screen. I've had sets with screens of all sizes from 9 to 17 inches working in the house and my considered opinion, with which Mrs. Diallist entirely agrees, is that the 12-inch screen has it every time. With spot wobble we find screen sizes up to 15 inches acceptable so far as picture quality is concerned.

The Ideal Receiver

Now, I've talked over this question of screen size with quite a lot of discriminating people, people who know what they want and don't care two hoots about "keeping up with the Joneses"—for that, I think, is mainly what incites to the use of quart-sized television receivers in pint-sized rooms. I've found a remarkably large majority in favour of the 12-inch screen. And please don't jump to the conclusion that that's because they can't afford the bigger sets. On the contrary, many of them would be quite willing to pay a good deal more for absolutely first-rate 12-inch sets, if they could get them. Here are the things that they want and I believe firmly that any manufacturer who has the courage to market a *de luxe* 12-inch receiver will reap a golden harvest. The set must be a console with full-length doors. The a.f. stages and the loudspeaker must do full justice to the quality of the transmitted sound. The vision circuits must include fully effective amplification of the d.c. component, genuine 3-Mc/s definition, true interlace, a.g.c. that can take charge of aeroplane flutter, suppression of line flyback and absence of ringing effects and of the "drizzly" picture reproduction, which betokens too often either time base instability, or interaction between line and frame time bases. Add either spot wobble, or spot elongation by controlled astigmatism, and I believe that the luxury 12-inch set would sweep the board.

A TV Plaint

NO ONE COULD be more strongly in favour of the standardization of things in general use than I. I can't for the life of me see why in bathrooms the "h" and "c" shouldn't *always* be in the same relative positions. Or why you can't get out of any taxi by pushing *down* the same kind of thing in the same sort of position? It annoys me to find that what looks like the door handle is the thing that works the window, and that, when found, the door handle must be pushed *up*. So with television receivers and their controls. Not only are makers unable to label them with standard names, but each has his own ideas about those which should be placed at the front of the cabinet, at one of its sides, at the back of it, or inside it. Even when I have succeeded in memorizing their positions, I detest those rows of controls at the back of the set. Unless you can develop a swan-like neck, or arms like an orang-outang's how can you adjust line-linearity or contrast properly by means of knobs at the back of a cabinet measuring the best part of a couple of feet deep?

Running Riot?

THE NOTE in the April issue of *W.W.* on the latest edition of the British Standard on valve bases frankly horrified me. That BS448: 1953 should have to include at least 25 types of British valve bases is surely a rather awful thing. We seem to be getting farther and farther from any kind of rationalization and the existence of this unconscionable number of different valve bases can't be doing anybody (including those who make them) very much good. It can lead only to needlessly high costs, to waste of time and to other far from desirable consequences in the assembly and maintenance of electronic gear. Here, certainly, is a problem that should be tackled without delay.

UNBIASED

By FREE GRID

Leadless Listening

ONE OF THE most interesting developments of recent years is the "wireless headphone" system of reception installed a few months ago in Worthing Hospital whereby patients can hear the B.B.C. programmes without any wired link between their headphones and the hospital receiving set. A copper band around the ward feeds the programme inductively to special headphones worn by the patients. The system has many other applications and is used in the United Nations H.Q. as reported in *W.W.* in February last year.

Nearly strangled.

I am, however, far more interested in it from a domestic point of view as I am a great believer in listening to certain types of programme by means of headphones rather than the loudspeaker. The great disadvantage of headphones, of course, has been that if you get up hurriedly, such as to put the cat out and speed it on its way when it suddenly signals that its journey is really necessary, you are apt to strangle yourself with the phone cords.

These *wireless* phones would avoid this and, provided that every room was properly fitted with the necessary copper band, also enable you to roam the house at will and even to take a bath without interrupting your reception of the programme. I haven't actually put my ideas into practice but shall undoubtedly have done so by the time you read these words.

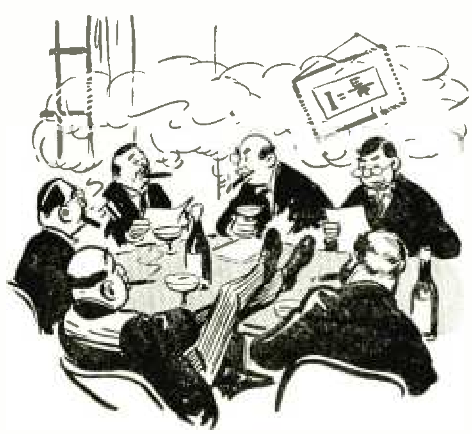
A Modern Jeroboam

HAVING BEEN very carefully brought up in my youth I always hold my elders and betters in great respect and never venture to contradict them. This applies as much to my technical as to my moral or ethical betters and even when one of them makes a statement which is contrary to my own knowledge and experience I naturally assume that I am the one at fault.

There have been occasions, however, when I have been so pig-headedly convinced that I have been right that I have momentarily felt rebellious. An instance of this occurred recently when I read a statement which was to the effect that constant switching on and off of an electric lamp made little or no difference to the life of its filament.

Since this statement could obviously be applied also to valve filaments I was at once interested more especially as it was made by a man who is, among other things, an A.M.I.E.E., and with whom, therefore, it would ill become me to disagree. Had he been outside the pale of that august assembly I should not have hesitated to contradict him for during the war when new valves were hard to get I held the opposite opinion so strongly that I left the heaters of my valves permanently on, putting in a special switch to cut off the h.t. when not using the set.

My reason for doing this was to help the national economy as I thought that the country could afford the extra electrical energy better than the additional valve replacements I should have needed if I had shortened filament life by constantly switching the l.t. supply on and off. I was, of course, labouring under the delusion that the repeated expansion and contraction of the filaments would lead to their early demise; in my ignorance I imagined that the effect would be the same as when you get hold of a piece of tinplate and bend it backwards and forwards in order to break it.



"*That august assembly.*

Unfortunately, I published my heretical opinions in these columns and advised my readers to follow my evil example. In thus leading my fellow countrymen astray I am, therefore, no better than "Jeroboam, the son of Nebat, who caused Israel to sin," and you know what happened to him. I suppose—perish the thought—that it isn't just possible that I may have been right after all?

Polarized Polyphony

AS YOU MAY have noticed I rarely remove my bowler. This is because it houses my personal portable which enables me to keep in touch with world affairs at all times, bone conduction being used in place of ugly and conspicuous earphones.

Recently, however, I felt compelled to remove it for a moment as a tribute to the sheer genius of the radio correspondent of a well-known London evening newspaper. He has invented or discovered the existence of—he does not make it quite clear which—a truly remarkable television set which has two screens and two loudspeakers facing in opposite directions. Now, you may rightly think that there is nothing very remarkable in that but you will change your opinion when I tell you that the two sections of the set operate simultaneously *on different programmes* without the slightest mutual interference.

So far as the vision side of the set is concerned there would obviously be no trouble but it was a long time before my rather limited intelligence was able to work out how it was possible for two forceful speakers to hold forth within a few feet of each other without causing acoustic chaos.

There is no suggestion of earphones being used with this remarkable new set and had I not had some experience of stereoscopic projection I might not have solved the problem. As you may know, in one method of stereo projection a vertical polarizing filter is placed in front of one of the two lenses and a horizontal one over the other and the wearing of similarly polarized glasses enables the two pictures to be separated.

When I remembered this, everything at once became clear to me. I am a bit rusty in acoustics but I suppose it must now be possible to apply this polarizing principle to sound. Obviously each loudspeaker has its own acoustic polarizing filter over its grille, and listeners wear filters in their ears corresponding to the loudspeakers to which they wish to listen.